5.0 CONSERVATION STRATEGY OPTION 3 EVALUATION

Using the methods described in Section 2, this section presents an evaluation of Option 3. Option 3 is evaluated based on how it addresses each of the evaluation criteria and how it performs relative to the other Options and base conditions.

5.1 BIOLOGICAL CRITERIA

Option 3 includes construction and operation of a series of barriers designed to reduce the effects of SWP and CVP export operations on hydraulic conditions and habitat for covered species within Old River and the central region of the Delta (Figure 1-4). Option 3 also includes the construction and operation of an intake facility with a state-of-the-art- positive barrier fish screen located on the Sacramento River in the vicinity of Hood. Diversions would be made preferentially from the Hood facility, however, diversions would also be made from the south Delta. To accommodate through-Delta water conveyance under Option 3 the primary locations of potential physical habitat restoration and enhancement measures are expected to be in the northern reaches of the Delta (e.g., Cache Slough area, Yolo Bypass, Sutter and Steamboat Sloughs), in Suisun Marsh, and in the central region of the Delta (Figure 1-4). Results of the assessment of biological criteria and potential benefits to the covered fish species under Option 3 are described in this section.

The evaluation of biological criteria for Option 3 is based on the hydrodynamic parameter values modeled for operational Scenarios A and B. The evaluation discussions presented below for each species and criterion, however, focus on Scenario A because:

- the type of effects of Scenario B on stressors and stressor impact mechanisms for each of the covered fish species are the same as described for Scenario A and a description of the performance of Scenario B would be repetitious;

- Scenario A would be more likely to achieve water supply objectives than Scenario B and, therefore, comparison of hydrodynamic outputs for scenario A across the Options puts each Option on an equivalent basis; and

- The magnitude of the effects of the Option on covered fish species differs between Scenarios A and B and, consequently, CALSIM II and DSM2 modeling results for Scenario B provided information useful in determining the range of flexibility within the Option to improve performance of the Option relative to achieving each of the biological criteria.

Though not described in the criteria evaluation text, the expected performance of Scenario B on each of the important stressors for each of the covered fish species relative to the performance of Scenario A is presented in summary tables at the beginning of each species evaluation section below.

Descriptions of the stressors and impact mechanisms addressed by the Options relative to each of the biological criteria and the tools used to measure changes in stressor effects are described in Section 3, "Conservation Strategy Option 1 Evaluation", and are not repeated in this section.

5.1.1 Delta Smelt

Based on the evaluation presented below of the expected performance of Option 3 for addressing important delta smelt stressors, Option 3 would be expected to have a moderate beneficial effect on delta smelt production, distribution, and abundance relative to base conditions when operated to meet water supply objectives (Scenario A). If water supply exports are reduced (Scenario B), Option 2 would also be expected to provide a moderate beneficial effect on delta smelt production, distribution, and abundance relative to base conditions. Option 3 would be expected to provide higher benefits for delta smelt compared to Options 1 and 2, but lower benefits compared to Option 4.

Table 5-1 summarizes the expected effects of implementing Option 3 under Scenarios A and B on important delta smelt stressors relative to base conditions.

Table 5-1. Summary of Expected Effects of Option 3 on Highly and Moderately Important Delta Smelt Stressors

Stressors[1]	Applicable Criteria	Option Effects on Important Species Stressors Relative to Base Conditions	
		Scenario A	Scenario B
Highly Important Stressors			
Reduced food availability	1,3,4,5	Moderate benefit	Moderate benefit
Reduced rearing habitat	2,3	Moderate benefit	Moderate benefit
Reduced turbidity	1,2,3,5	Moderate benefit	Moderate benefit
Reduced spawning habitat	3	Moderate benefit	Moderate benefit
Reduced food quality	1,4,5	Moderate benefit	Moderate benefit
Moderately Important Stressors			
Predation	1,5	Moderate benefit	Moderate benefit
CVP/SWP entrainment[2]	1	High benefit	High benefit
Exposure to toxics	1,2	Moderate adverse effect	Moderate adverse effect

Notes:

1. See Appendix C for descriptions of stressors, stressor impact mechanisms, and stressor effects.
2. Although it is recognized that the risk of entrainment at the SWP and CVP export facilities may, in some years, be a high level stressor to delta smelt, and in some years represents a very low level stressor to delta smelt, for purposes of the analysis the risk of delta smelt entrainment under each of the Options has been characterized, on average, as a moderate level stressor to the population.

5.1.1.1 Criterion #1. Relative degree to which the Option would reduce species mortality attributable to non-natural mortality sources, in order to enhance production (reproduction, growth, survival), abundance, and distribution for each of the covered fish species.

Based on the following evaluation of Option 3 effects on applicable delta smelt stressors, Option 3 is expected to provide moderate benefits for delta smelt by reducing the effects of non-natural sources of mortality relative to base conditions.

Reduced Food Availability and Quality

The effects of Option 3 on delta smelt food availability and quality are evaluated under Criterion #4 below. As described in the Criterion #4 evaluation, Option 3 would be expected to provide a moderate beneficial effect on food availability and a moderate beneficial effect on food quality for the delta smelt relative to base conditions.

Reduced Turbidity

The effects of Option 3 on turbidity are evaluated under Criterion #2 below. As described in the Criterion #2 evaluation, Option 3 would be expected to provide moderate beneficial increase in turbidity conditions for delta smelt.

Predation

As described below under Criterion #2, Option 3 would be expected to improve turbidity conditions relative to base conditions and, therefore, would be expected to reduce the vulnerability of delta smelt to predation. The proportion of the Delta (35%) within which habitat restoration could potentially be implemented is greater than under Option 1, the same as under Option 2, but less than under Option 4 (see Figure 1-4). Based on the potential for improvement in turbidity conditions and the proportion of the Delta available for restoration, Option 3 would be expected to provide a moderate benefit by reducing the predation vulnerability of delta smelt relative to base conditions.

Entrainment by CVP/SWP Facilities[1]

In Middle River, which is designated as the conveyance corridor to move water through the Delta to the export facilities, PTM modeling results indicated that entrainment was greater relative to base conditions when SWP and CVP exports were being made from the south Delta. Other than from the Middle River insertion location, there was a substantial reduction in entrainment of particles by the SWP/CVP exports. In Middle River, which is designated as the conveyance corridor to move water through the Delta to the export facilities, entrainment was greater than base conditions. In reality, however, there should be very few or no larval or juvenile delta smelt in Middle River relative to base conditions and Option 1 because they would be blocked from entering the corridor from the west by the structural barriers. Risk for

[1]Modeling results for reverse flows in Old and Middle River are not used in the assessment of this stressor under Option 3 because Old River flows are isolated from the CVP/SWP pumping facilities and modeled reverse flow results for Old River cannot be disaggregated from results for Middle River.

entrainment into Middle River, however, would be increased during periods of reverse flow in the San Joaquin River, but would be expected to be lower than under Option 2 which would pump water from Middle River through the siphon.

Risk for entrainment of delta smelt at the Hood intake facility would be minimal because the intake would be equipped with a positive barrier fish screen that would be expected to be highly effective in reducing the vulnerability of all but the early larval stages of delta smelt to entrainment. Furthermore, most delta smelt are believed to spawn downstream of the proposed Hood intake location, thus reducing the proportion of the delta smelt population that is vulnerable to entrainment.[2] The proportion of the population, however, that could be vulnerable to entrainment could increase in future years as sea levels rise sufficiently to move spawning upstream from current locations. Under Option 3 delta smelt would continue to be vulnerable to entrainment and salvage at the south Delta export facilities to the extent that water is exported from the south Delta under this Option. PTM modeling results indicate that the percentage of particles entrained by SWP and CVP exports under Option 3 would be negligible from most insertion locations and flow conditions (see Appendices F and H). The only insertion location from which particles were entrained regularly was Middle River. The index of vulnerability to SWP and CVP salvage for delta smelt shows a substantial decrease in the risk of smelt salvage under Option 3 when compared to base conditions and Options 1 or 2 (see Appendices F and H). Consequently, Option 3 would be expected to provide a high benefit for delta smelt by substantially reducing the likelihood for entrainment of delta smelt relative to base conditions.

Exposure to Toxics

The effects of Option 3 on delta smelt exposure to toxics are evaluated under Criterion #2 below. As described in the Criterion #2 evaluation, Option 3 would be expected to have a moderate adverse increase in delta smelt exposure to toxics.

5.1.1.2 Criterion #2. Relative degree to which the Option would provide water quality and flow conditions necessary to enhance production (reproduction, growth, survival), abundance, and distribution for each of the covered fish species.

Based on the following evaluation of Option 3 effects on applicable delta smelt stressors, Option 3 is expected to have a low beneficial effect on water quality and flow conditions that support delta smelt relative to base conditions.

Reduced Rearing Habitat

Results of hydrologic modeling indicate that the position of X_2 in April would be located upstream relative to base conditions and therefore could result in a slight reduction in the availability of rearing habitat. Net downstream flows and Sacramento River flows at Rio Vista during March and April, which serve to transport larval smelt to downstream rearing habitats, would be reduced relative to base conditions (see Appendices F and H). PTM modeling results,

[2] Results of fishery surveys conducted by CDFG and USFWS have shown that the majority of delta smelt inhabit the Sacramento River downstream of Walnut Grove and Georgiana Slough although a small number of delta smelt have been collected upstream of Hood in some years.

however, indicate that more particles would move downstream of Chipps Island relative to base conditions. As described below, Option 3 would be expected to improve turbidity conditions, thus improving the foraging efficiency of delta smelt and reducing their vulnerability to predation. The potential restoration of rearing habitats as described under Criterion #3 would also be expected to improve rearing habitat conditions. Consequently, overall Option 3 would be expected to have a moderate beneficial effect on delta smelt rearing habitat conditions relative to base conditions.

Reduced Turbidity

Option 3 is expected to moderately improve turbidity conditions for delta smelt relative to base conditions. Peak total Delta inflows from January through March are reduced from base conditions, indicating that turbidity inputs from Delta tributaries could be reduced from base conditions in those months. PTM modeling results for the central Delta indicate, however, that residence time would be substantially higher, thus creating the potential for increases in turbidity associated with primary and secondary production (see Appendices F and H). Restoration of aquatic subtidal and intertidal habitats that could reduce the impacts of non-native aquatic pelagic and benthic organisms that filter sediment and organic materials from Delta waters could occur within approximately 35% of the Delta (Figure 1-4). Although peak Delta inflows could be reduced, improved turbidity conditions associated with increased hydraulic residence time and habitat restorations would be such that, overall, Option 3 would be expected to provide a moderate beneficial improvement in turbidity conditions for delta smelt relative to base conditions.

Exposure to Toxics

Dilution flows from the Sacramento River and other Delta tributaries are one way of reducing concentrations of toxics and their effect on delta smelt. Modeling results indicate that Option 3 would be expected to reduce dilution flows relative to base conditions, thus potentially increasing concentrations of toxics (see Appendices F and H). As described for Option 2, there is also the potential for the physical configuration of Option 3 to cause an increase in toxic loading in the area of the central Delta that is available for restoration (Figure 1-4). The configuration of barriers and the siphon to transport San Joaquin River water into the central Delta would potentially increase toxic loading to the central Delta by reducing the dilution of higher concentrations of toxics and salinity originating within the San Joaquin River watershed. Although the effects of toxics on delta smelt are uncertain, Option 3 has the potential for having a moderate adverse effect on delta smelt by increasing the exposure of delta smelt to higher concentrations of toxics.

5.1.1.3 Criterion #3. Relative degree to which the Option would increase habitat quality, quantity, accessibility, and diversity in order to enhance and sustain production (reproduction, growth, survival), abundance, and distribution; and to improve the resiliency of each of the covered species' populations to environmental change and variable hydrology.

Based on the following evaluation of Option 3 effects on applicable delta smelt stressors, Option 3 is expected to provide moderate benefits relative to habitat conditions for the delta smelt.

Within the planning area, delta smelt habitat conditions are governed by hydrodynamic conditions and the extent and quality of habitat within the planning area. Under Option 3, these conditions relative to base conditions would be affected by the conveyance configuration of Option 3 and restoration of physical habitat that could be sited within Suisun Bay and Marsh and within the planning area in the north and west Delta, which represents approximately 35% of the planning area.

Reduced Food Availability

The effects of Option 3 on delta smelt food availability are evaluated under Criterion #4 below. As described in the Criterion #4 evaluation, Option 3 would be expected to provide a moderate beneficial effect on food supply for the delta smelt relative to base conditions.

Reduced Rearing Habitat

Under Option 3, in addition to the flow benefits for rearing habitat conditions described above under Criterion #2, habitat could be restored within Suisun Bay and Marsh and approximately 35% of the Delta to provide high quality shallow aquatic subtidal and intertidal habitat (Figure 1-4), which encompasses a larger proportion of the delta smelts rearing range than restoration that could be implemented under Option 1, the same proportion as under Option 2, and a smaller proportion than under Option 4. Consequently, relative to base conditions and the other Options, Option 3 would be expected to provide a moderate benefit for delta smelt rearing habitat.

Reduced Turbidity

The effects of Option 3 on turbidity are evaluated under Criterion #2 above. As described in the Criterion #2 evaluation, Option 3 would be expected to provide moderate beneficial increases in turbidity conditions.

Reduced Spawning Habitat

The primary impact mechanism believed to affect spawning habitat is the reclamation and channelization of historical shallow subtidal and intertidal wetlands that has presumably reduced the amount of habitat available for spawning by delta smelt. Under Option 3, habitat could potentially be restored within Suisun Bay and Marsh and approximately 35% of the Delta to provide high quality aquatic habitat under this Option (Figure 1-4), which encompasses a slightly larger proportion of the likely spawning range of delta smelt than restoration that could be implemented under Option 1, the same proportion as Option 2, and smaller proportion than Option 4. Consequently, relative to the other Options and to the extent that functioning delta smelt spawning habitat can be successfully restored based on current understanding of its habitat requirements, restoration under Option 3 would be expected to provide a moderate benefit (see Appendix H) relative to base conditions.

5.1.1.4 Criterion #4. Relative degree to which the Option would increase food quality, quantity, and accessibility (e.g., phytoplankton, zooplankton, macro-invertebrates, forage fish) to enhance production (reproduction, growth, survival) and abundance for each of the covered fish species.

Overall, Option 3 would be expected to provide moderate benefits for improving food availability and quality for delta smelt.

Reduced Food Availability

The habitat restoration that would potentially be implemented under Option 3 would all be located within the geographic range of delta smelt and could create conditions that disfavor non-native species that indirectly or directly affect food abundance (e.g., overbite clam (*Corbula*), threadfin shad), thereby improving food availability for delta smelt relative to base conditions (Figure 1-4). The potential opportunity for habitat restoration is expected improve food availability relative to Option 1, would be the same relative to Option 2, and less than under Option 4.

Floodplains are highly productive and are thought to be a source of high amounts of allochthonous nutrient and organic carbon production from the terrestrial community that inhabits the floodplain and upland areas during the remainder of the year (Sommer et al. 2001, Harrell and Sommer 2003). The magnitude of peak flows from January through March, the period during which inflows have been greatest into the Delta historically, gives an indication of the potential for floodplain inundation relative to base conditions. Modeled peak Delta inflows under Option 3 during January through March are substantially lower relative to base conditions (see Appendices F and H). Therefore, relative to base conditions, Option 3 would be expected to have a low adverse effect on the transport of organic material and nutrients from floodplains into the Delta.

Based on PTM modeling results for exported particles, the removal of food organisms, nutrients, and organics by diversions would be appreciably lower relative to base conditions. PTM modeling results for particles released into the central Delta, an indicator of hydrologic residence time, indicated that hydraulic residence time within the central Delta was greater relative to base conditions. Based on these results, Option 3 would be expected to provide a moderate benefit for delta smelt associated with a reduction in exports of nutrients and organic material that support delta smelt food supplies.

Reduced Food Quality

Restoration of shallow water tidal and subtidal habitats under Option 3 could improve nutrient production and production of suitable zooplankton species (e.g., native calanoid copepods) as forage for delta smelt. Under Option 3, habitat could potentially be restored within Suisun Bay and Marsh and approximately 35% of the Delta to provide high quality aquatic habitat under this Option (Figure 1-3), which encompasses a larger proportion of the delta smelt's range than restoration that could be implemented under Option 1, the same proportion as under Option 2, but less than under Option 4. Consequently, relative to the other Options, Option 3 would be expected to provide a moderate benefit for food quality (see Appendix H).

5.1.1.5 Criterion #5. Relative degree to which the Option would reduce the abundance of non-native competitors and predators to increase native species production (reproduction, growth, survival), abundance and distribution for each of the covered fish species.

Option 3 could reduce the effects of non-native competitors and predators on delta smelt primarily through restoration of shallow water subtidal and intertidal and aquatic habitats in the north and central Delta. For reasons described above, Option 3 would be expected to provide a moderate beneficial effect by reducing the potential adverse effects of populations of non-native food competitors relative to base conditions. For reasons described under Criteria #1 and #2, Option 3 could provide a moderate beneficial effect by reducing the risk of delta smelt predation relative to base conditions. Additionally, the flexibility provided by dual conveyance facilities and operable barriers provides the opportunity under Option 3 to adaptively manage Delta hydrodynamics to create hydrodynamic conditions that favor the delta smelt and disfavor predators and competitors to improve conditions for the delta smelt. Although the ability to control non-native species by varying hydrodynamic conditions in the Delta is uncertain, Option 3 provides the greatest opportunity for doing so among the Options.

5.1.1.6 Criterion #6. Relative degree to which the Option improves ecosystem processes in the BDCP planning area to support aquatic and associated habitats.

Based on the proportion of the planning area potentially available and suitable for restoration under Option 3 relative to the other Options and modeling results for hydraulic residence time (see Appendix H), Option 3 would be expected to provide a moderate beneficial improvement in ecosystem function relative to base conditions.

Under the range of operations and the potential opportunities to restore/enhance high quality aquatic habitat within the Delta habitat, the effectiveness of Option 3 in improving ecosystem processes is considered to be moderate. Middle River would continue to serve as the water conveyance facility for freshwater supplies moving from the Sacramento River across the Delta to the export facilities located in the southern Delta. Movement of large volumes of water through Middle River would adversely affect hydraulic conditions, require dredging to increase conveyance capacity, and may require additional riprap to reduce levee scour and erosion. These conditions would degrade the quality of fishery habitat within Middle River. In contrast, the area adjacent to Old River and the central and western portion of the Delta would be improved by isolating these areas from the effects of export operations and by increasing residence times within the central Delta thereby reducing the export of nutrients, organic carbon, phytoplankton, and zooplankton from the Delta and increasing aquatic food production and availability. These changes would be expected to improve ecosystem processes within the central and western regions of the Delta when compared to base conditions. In addition, the ability to divert water directly from the Sacramento River at Hood while reducing the export operations within the south Delta would be expected to substantially improve the hydrodynamics of the Delta and improve the quality of habitat available for delta smelt. Under these operating conditions Option 3 offers the opportunity to improve the processes affecting habitat conditions within the Delta (e.g., providing net westerly flows, reducing or eliminating reverse flow conditions, etc.). These potential changes to the estuarine processes within the Delta are expected to benefit delta smelt and other species. It is uncertain, however, if the discharge of low quality San Joaquin River water into the central Delta would impair ecosystem processes.

5.1.1.7 Criterion #7. Relative degree to which the Option can be implemented within a timeframe to meet the near-term needs of each covered fish species (post BDCP authorization).

In the near-term, until construction of Option 3 conveyance features and facilities is completed, Option 3 would use the existing conveyance facilities to meet water supply objectives. As for Option 1, implementation of physical habitat restoration under Option 3 in the north and west Delta can be initiated immediately following authorization of the BDCP and thus could be implemented in a manner that would meet the near-term needs of delta smelt.

5.1.2 Longfin Smelt

Based on the evaluation presented below of the expected performance of Option 3 for addressing important longfin smelt stressors, Option 3 would be expected to have a moderate beneficial effect on longfin smelt production, distribution, and abundance relative to base conditions when operated to meet water supply objectives (Scenario A). If water supply exports are reduced (Scenario B), Option 3 would also be expected to provide a moderate beneficial effect on longfin smelt production, distribution, and abundance relative to base conditions. Option 3 would be expected to provide higher benefits for longfin smelt compared Options 1 and 2, but lower benefits compared to Option 4.

Stressors that affect longfin smelt are presented in Figure 2-2 and are described in Appendix C. The effect of these stressors on the longfin smelt population vary among years in response to environmental conditions (e.g., seasonal hydrology) and may also interact with each other in additive or synergistic ways. The effects of these stressors include both the incremental contribution of a stressor to the population as well as the cumulative effects of multiple stressors over time. The assessment of Option 3 evaluates the degree to which Option 3 would be expected to address these stressors.

Table 5-2 summarizes the expected effects of implementing Option 3 under Scenarios A and B on important longfin smelt stressors relative to base conditions.

Table 5-2. Summary of Expected Effects of Option 3 on Highly and Moderately Important Longfin Smelt Stressors

Stressors[1]	Applicable Criteria	Option Effects on Important Species Stressors Relative to Base Conditions	
		Scenario A	Scenario B
Highly Important Stressors			
Reduced access to spawning habitat	2	Very low adverse effect	Moderate benefit
Reduced access to rearing habitat	2	Low benefit	Moderate benefit
Reduced food	1,4,5	Moderate benefit	Moderate benefit
Predation	1,5	Moderate benefit	Very low benefit
Reduced turbidity	1,2, 3,5	Moderate benefit	Low benefit
Reduced spawning habitat	3	Low benefit	Very low benefit
Reduced food quality	1,4,5	Moderate benefit	Very low benefit

Table 5-2. Summary of Expected Effects of Option 3 on Highly and Moderately Important Longfin Smelt Stressors (continued)

Stressors[1]	Applicable Criteria	Option Effects on Important Species Stressors Relative to Base Conditions	
		Scenario A	Scenario B
Moderately Important Stressors			
CVP/SWP entrainment[2]	1	High benefit	Moderate benefit
Reduced rearing habitat	2	Low benefit	Moderate benefit
Exposure to toxics	2	Moderate adverse effect	Low adverse effect

Notes:

1. See Appendix C for descriptions of stressors, stressor impact mechanisms, and stressor effects.
2. Although it is recognized that the risk of entrainment at the SWP and CVP export facilities may, in some years, be a high level stressor to longfin smelt, and in some years represents a very low level stressor to longfin smelt, for purposes of the analysis the risk of longfin smelt entrainment under each of the Options has been characterized, on average, as a moderate level stressor to the population.

5.1.2.1 Criterion #1. Relative degree to which the Option would reduce species mortality attributable to non-natural mortality sources, in order to enhance production (reproduction, growth, survival), abundance, and distribution for each of the covered fish species.

Based on the following evaluation of Option 3 effects on applicable longfin smelt stressors, Option 3 is expected to provide moderate benefits for longfin smelt by reducing the effects of non-natural sources of mortality relative to base conditions.

Reduced Food Availability and Quality

Reduced food availability and quality can result in non-natural levels of mortality. The effects of Option 3 on longfin smelt food availability and quality are evaluated under Criterion #4 below. As described in the Criterion #4 evaluation, Option 3 would be expected to provide a moderate beneficial effect on food availability and quality for longfin smelt relative to base conditions.

Reduced Turbidity

Reduced turbidity may increase the vulnerability of longfin smelt to predation and reduce foraging efficiency. The effects of Option 3 on turbidity are evaluated under Criterion #2 below. As described in the Criterion #2 evaluation, Option 3 would be expected to provide moderate beneficial increases in turbidity conditions relative to base conditions.

Predation

As described below under Criterion #2, Option 3 would be expected to provide a moderate improvement in turbidity conditions relative to base conditions and, therefore, would be expected to reduce the vulnerability of longfin smelt to predation. The proportion of the Delta (35%) within which habitat could potentially be implemented is greater than under Option 1, the same the same as under Option 2, but less than under Option 4 (see Figure 1-3). Based on the potential for improvements in turbidity conditions and the proportion of the Delta available for restoration, Option 3 would be expected to provide a moderate benefit by reducing the predation vulnerability of longfin smelt relative to base conditions.

Entrainment by CVP/SWP Facilities[3]

In Middle River, which is designated as the conveyance corridor to move water through the Delta to the export facilities, PTM modeling results indicated that entrainment under Option 3 is expected to be greater relative to base conditions. Other than from the Middle River insertion location, there would a substantial reduction in entrainment of particles by the SWP/CVP exports. The isolation of Old River and adjacent areas from the hydraulic effects of SWP and CVP export operations (e.g., reducing and avoiding reverse flows within Old River) are expected to benefit longfin smelt under Option 3 as would preferential diversion of water from the Sacramento River using a positive barrier fish screen when compared to base conditions. In Middle River, which is designated as the conveyance corridor to move water through the Delta to the export facilities, entrainment would be greater than base conditions. In reality, however, there should be very few or no larval or juvenile longfin smelt in Middle River relative to base conditions and Option 1 because they would be blocked from entering the corridor from the west by the structural barriers. Risk for entrainment into Middle River, however, would be increased during periods of reverse flow in the San Joaquin River, but would be expected to be lower than under Option 2 which would pump water from Middle River through the siphon. Reduction in the occurrence of reverse flows within Middle River under Option 3 through use of the Hood diversion would also benefit longfin smelt through both improved habitat conditions within the Delta as well as a reduction in the risk of entrainment and salvage losses.

Longfin smelt are primarily distributed downstream of the vicinity of Hood within the Sacramento River and, therefore, would not be at risk for entrainment at the Hood intake facility. In the event that longfin smelt do occur near the Hood diversion location, the risk for entrainment of adult longfin smelt would be minimal because the intake would be equipped with a positive barrier fish screen. Longfin smelt, however, could become vulnerable to entrainment in future years if sea levels rise sufficiently to move spawning upstream from current locations. The Hood intake facility would, however, be equipped with a positive barrier fish screen that would be expected to be highly effective in reducing the vulnerability of all but the early larval stages of longfin smelt to entrainment should their range extend upstream in future years. Under Option 3 longfin smelt would continue to be vulnerable to entrainment and salvage at the south Delta export facilities to the extent that water is exported from the south

[3]Modeling results for reverse flows in Old and Middle River are not used in the assessment of this stressor under Option 3 because Old River flows are isolated from the CVP/SWP pumping facilities and modeled reverse flow results for Old River cannot be disaggregated from results for Middle River.

Delta under this Option. PTM modeling results indicate that the percentage of particles entrained by SWP and CVP exports under Option 3 would be negligible from most insertion locations and flow conditions (see Appendices F and H). The only insertion location from which particles were entrained regularly was Middle River. The index of vulnerability to SWP and CVP salvage for longfin smelt shows a substantial decrease in the risk of smelt salvage under Option 3 when compared to base conditions and Options 1 and 2 (see Appendices F and H). Consequently, Option 3 would be expected to provide a high benefit by substantially reducing the likelihood for entrainment of longfin smelt relative to base conditions.

Exposure to Toxics

The effects of Option 3 on longfin smelt exposure to toxics are evaluated under Criterion #2 below. As described in the Criterion #2 evaluation, Option 3 would be expected to have a moderate adverse increase in longfin smelt exposure to toxics.

5.1.2.2 Criterion #2. Relative degree to which the Option would provide water quality and flow conditions necessary to enhance production (reproduction, growth, survival), abundance, and distribution for each of the covered fish species.

Based on the following evaluation of Option 3 effects on applicable longfin smelt stressors, Option 3 is expected to provide very low benefits for water quality and flow conditions that support longfin smelt relative to base conditions.

Reduced Access to Spawning Habitat

Access of adult longfin smelt to spawning habitat is thought to be a function of river flows and availability and quality of habitat. Under Option 3 flows within the Sacramento River during the late winter and early spring longfin smelt spawning period are expected to be lower than base conditions. Lower winter and early spring flows may reduce upstream attraction and movement of adult longfin smelt and would also be expected to contribute to reduce downstream transport of larval and early juvenile smelt. Flows on the San Joaquin River have been assumed, for purposes of these analyses, to be similar under base conditions and Option 3. Option 3 includes the opportunity to potentially enhance intertidal and subtidal habitat in the lower Sacramento River and northern Delta that would be expected to benefit longfin smelt when compared to base conditions.

Reduced Access to Rearing Habitat

Net downstream flows are important for transporting planktonic larval longfin smelt downstream towards suitable rearing habitat in the western Delta and Suisun Bay. PTM modeling results indicate that the percentage of particles that moved past Chipps Island or into Suisun Bay during the early spring would be marginally lower under Option 3 relative to base conditions (see Appendices E and H).

Net downstream flows and Sacramento River flows at Rio Vista during March and April, which serve to transport larval smelt to downstream rearing habitats, would be reduced relative to base conditions (see Appendices F and H). As described below, Option 3 would be expected to improve turbidity conditions, thus improving the foraging efficiency of longfin smelt and

reducing their vulnerability to predation. Consequently, overall Option 3 would be expected to have a low beneficial effect on longfin smelt accessibility to rearing habitats.

Reduced Turbidity

Option 3 is expected to moderately improve turbidity conditions for longfin smelt relative to base conditions. Peak total Delta inflows from January through March are reduced from base conditions, indicating that turbidity inputs from Delta tributaries could be reduced from base conditions in those months. PTM modeling results for the central Delta indicate, however, that residence time would be substantially higher, thus creating the potential for increases in turbidity associated with primary and secondary production (see Appendices F and H). Restoration of aquatic subtidal and intertidal habitats that could reduce the abundance and/or impacts of non-native aquatic pelagic and benthic organisms that filter sediment and organic materials from Delta waters could occur within approximately 35% of Delta (Figure 1-4). Although peak Delta inflows could be reduced, improved turbidity conditions associated with increased hydraulic residence time and habitat restorations would be such that, overall, Option 3 would be expected to provide a moderate beneficial improvement in turbidity conditions for longfin smelt relative to base conditions.

Reduced Rearing Habitat

Results of hydrologic modeling indicate that the position of X_2 in April would be located upstream relative to base conditions and, therefore, could result in a slight reduction in the availability of rearing habitat. As described below, Option 3 would be expected to improve turbidity conditions, thus improving the foraging efficiency of longfin smelt and reducing their vulnerability to predation. Consequently, overall Option 3 would be expected to have a low beneficial effect on longfin smelt rearing habitat conditions relative to base conditions.

Exposure to Toxics

Dilution flows from the Sacramento River and other Delta tributaries are one way of reducing concentrations of toxics and their effect on longfin smelt. Modeling results indicate that Option 3 would be expected to reduce dilution flows relative to base conditions, thus potentially increasing concentrations of toxics (see Appendices F and H). As described for Option 2, there is also the potential for the physical configuration of Option 3 to cause an increase in toxic loading in the area of the central Delta that is available for restoration (Figure 1-4). The configuration of barriers and the passage of San Joaquin River water into the central Delta would potentially increase toxic loading to the central Delta by reducing the dilution of higher concentrations of toxics and salinity originating within the San Joaquin River watershed. Although the effects of toxics on longfin smelt are uncertain, Option 3 has the potential for having a moderate adverse effect on longfin smelt by increasing the exposure of longfin smelt to higher concentrations of toxics.

5.1.2.3 Criterion #3. Relative degree to which the Option would increase habitat quality, quantity, accessibility, and diversity in order to enhance and sustain production (reproduction, growth, survival), abundance, and distribution; and to improve the resiliency of each of the covered species' populations to environmental change and variable hydrology.

Based on the following evaluation of Option 3 effects on applicable delta smelt stressors, Option 3 is expected to provide low benefits relative to habitat conditions for the delta smelt.

Within the planning area, longfin smelt habitat conditions are governed by hydrodynamic conditions and the extent and quality of habitat. Under Option 3, these conditions relative to base conditions would be affected by the conveyance configuration of Option 3 and the opportunities for restoration of physical habitat that could be sited within Suisun Bay and Marsh and within the planning area in the north, central, and west Delta, which represents approximately 35% of the planning area.

Reduced Access to Spawning and Rearing Habitats

The effects of Option 3 on the accessibility of spawning and rearing habitats are evaluated under Criterion #2 above. As described in the Criterion #2 evaluation, Option 3 would be expected to have a very low adverse effect on accessibility of spawning habitat and a low beneficial effect on accessibility of rearing habitat relative to base conditions.

Reduced Food Availability and Quality

Reduced food availability and quality can result in non-natural levels of mortality. The effects of Option 3 on longfin smelt food availability and quality are evaluated under Criterion #4 below. As described in the Criterion #4 evaluation, Option 3 would be expected to provide a moderate beneficial effect on food availability and quality for longfin smelt relative to base conditions.

Reduced Turbidity

Habitat conditions that support non-native filter feeders and aquatic plants can reduce turbidity. The effects on turbidity associated with these impact mechanisms are evaluated under Criterion #2 above. As described in the Criterion #2 evaluation, restoring habitat under Option 3 would be expected to have a moderate beneficial effect on turbidity conditions for longfin smelt relative to base conditions.

Reduced Spawning Habitat

Under Option 3 approximately 35% of the planning area would available for restoration/ enhancement of aquatic subtidal and intertidal habitats (Figure 1-3), which encompasses much of the geographic range of longfin smelt within the Delta (Rosenfield and Baxter, in press). Spawning habitat for longfin smelt would be expected to increase in response to habitat restoration/enhancement actions. Habitat restoration under Option 3, given the improved Delta hydrodynamic conditions that would be expected under Option 3, would likely provide a low benefit to longfin smelt.

Reduced Rearing Habitat

The effects on rearing habitat associated with Option 3 are evaluated under Criterion #2 above. Option 3 is expected to have a low beneficial effect on longfin smelt rearing conditions relative to base conditions.

5.1.2.4 Criterion #4. Relative degree to which the Option would increase food quality, quantity, and accessibility (e.g., phytoplankton, zooplankton, macro-invertebrates, forage fish) to enhance production (reproduction, growth, survival) and abundance for each of the covered fish species.

Overall, Option 3 would be expected to provide moderate benefits for improving food availability and quality for longfin smelt.

Reduced Food Availability

The habitat restoration that could potentially be implemented under Option 3 would all be located within the geographic range of longfin smelt and could create conditions that disfavor non-native species that indirectly or directly affect food abundance (e.g., overbite clam (*Corbula*), threadfin shad), thereby improving food availability for longfin smelt relative to base conditions (Figure 1-4). Habitat restoration is expected improve food availability relative to Option 1, would be the same relative to Option 2, and less than under Option 4.

Floodplains are highly productive and are thought to be a source of high amounts of allochthonous nutrients and organic carbon production from the terrestrial community that inhabits the floodplain and upland areas during the remainder of the year (Sommer et al. 2001, Harrell and Sommer 2003). The magnitude of peak flows from January through March, the period during which inflows have been greatest into the Delta historically, gives an indication of the potential for floodplain inundation relative to base conditions. Modeled peak Delta inflows under Option 3 during January through March are substantially lower relative to base conditions (see Appendices F and H). A reduction in peak flows would be expected to result in a reduction in the frequency and duration of seasonal floodplain inundation and a corresponding reduction in the mobilization and downstream transport of nutrients and organic material. Therefore, relative to base conditions, Option 3 would be expected to have a low adverse effect on the transport of organic material and nutrients from floodplains into the Delta.

Based on PTM modeling results for exported particles, the removal of food organisms, nutrients, and organics by diversions would be appreciably lower relative to base conditions. PTM modeling results for particles released into the central Delta, an indicator of hydrologic residence time, indicated that hydraulic residence time within the central Delta was greater relative to base conditions. Based on these results, Option 3 would be expected to provide a moderate benefit for longfin smelt associated with a reduction in exports of nutrients and organic material that support longfin smelt food supplies as well as an increase in residence time that would be expected to contribute to increased phytoplankton and zooplankton production within the Delta.

It has been hypothesized that exposure of phytoplankton and zooplankton to toxics (e.g., pesticides, herbicides) that enter the Delta from point and non-point sources may contribute to ongoing low abundance of longfin smelt zooplankton prey species (Weston et al. 2004, Luoma 2007). Though this relationship is uncertain, Option 3 would be unlikely to reduce the exposure of primary and secondary producers to these toxics because dilution flows would be lower than under base conditions.

Reduced Food Quality

Restoration of shallow water tidal and subtidal habitats under Option 3 could improve nutrient production and production of suitable zooplankton species (e.g., native calanoid copepods) as forage for longfin smelt. Under Option 3, habitat could potentially be restored within Suisun Bay and Marsh and approximately 35% of the Delta to provide high quality aquatic habitat under this option (Figure 1-3), which encompasses a larger proportion of the longfin smelt's range than restoration that could be implemented under Option 1 and the same proportion as under Option 2, but less than under Option 4. Consequently, relative to the other Options, Option 3 would be expected to provide a moderate benefit for food quality (see Appendix H).

5.1.2.5 Criterion #5. Relative degree to which the Option would reduce the abundance of non-native competitors and predators to increase native species production (reproduction, growth, survival), abundance and distribution for each of the covered fish species.

Option 3 could reduce the effects of non-native competitors and predators on longfin smelt primarily through restoration of intertidal and shallow subtidal aquatic habitats in the north, central, and western Delta. For reasons described above, Option 3 would be expected to provide a moderate beneficial effect by reducing the adverse impacts of populations of non-native food competitors relative to base conditions. For reasons described under Criteria #1 and #2, Option 3 could provide a low beneficial effect by reducing the risk of longfin smelt predation relative to base conditions. Additionally, the flexibility provided by dual conveyance facilities and operable barriers provides the opportunity under Option 3 to adaptively manage Delta hydrodynamics to create hydrodynamic conditions that favor the longfin smelt and disfavor predators and competitors to improve conditions for the longfin smelt. Although the ability to control non-native species by varying hydrodynamic conditions in the Delta is uncertain, Option 3 provides the greatest opportunity for doing so among the Options.

5.1.2.6 Criterion #6. Relative degree to which the Option improves ecosystem processes in the BDCP planning area to support aquatic and associated habitats.

Based on the proportion of the planning area suitable for restoration under Option 3 relative to the other Options and modeling results for hydraulic residence time (see Appendix H), Option 3 would be expected to provide a moderate beneficial improvement in ecosystem function relative to base conditions.

Under the range of operations and the potential opportunities to restore/enhance high quality aquatic habitat within the Delta habitat, the effectiveness of Option 3 in improving ecosystem processes is considered to be moderate. Middle River would continue to serve as the water conveyance facility for freshwater supplies moving from the Sacramento River across the Delta to the export facilities located in the southern Delta. Movement of large volumes of water

through Middle River would adversely affect hydraulic conditions, require dredging to increase conveyance capacity, and may require additional riprap to reduce levee scour and erosion. These conditions would degrade the quality of fishery habitat within Middle River. In contrast, the area adjacent to Old River and the central and western portion of the Delta would be improved by isolating these areas from the effects of export operations and by increasing residence times within the central Delta thereby reducing the export of nutrients, organic carbon, phytoplankton, and zooplankton from the Delta and increasing aquatic food production and availability. These changes would be expected to improve ecosystem processes within the central and western regions of the Delta when compared to base conditions. In addition, the ability to divert water directly from the Sacramento River at Hood while reducing the export operations within the south Delta would be expected to substantially improve the hydrodynamics of the Delta and improve the quality of habitat available for longfin smelt. Under these operating conditions Option 3 offers the opportunity to improve the processes affecting habitat conditions within the Delta (e.g., providing net westerly flows, reducing or eliminating reverse flow conditions, etc.). These potential changes to the estuarine processes within the Delta are expected to benefit longfin smelt and other species. It is uncertain, however, if the discharge of low quality San Joaquin River water into the central Delta would impair ecosystem processes.

5.1.2.7 Criterion #7. Relative degree to which the Option can be implemented within a timeframe to meet the near-term needs of each covered fish species (post BDCP authorization).

In the near-term, until construction of Option 3 conveyance features and facilities is completed, Option would use the existing conveyance facilities to meet water supply objectives. As for Option 1, implementation of physical habitat restoration under Option 3 in the north and west Delta can be initiated immediately following authorization of the BDCP and thus could be implemented in a manner that would meet the near-term needs of longfin smelt.

5.1.3 Sacramento River Salmonids

Overall, this Option will provide low benefit to Sacramento River Chinook salmon and steelhead compared to base conditions. Operations under Option 3 would result in reducing the risk of juvenile salmonid entrainment at the SWP and CVP export facilities and improve hydrodynamic conditions affecting habitat and migration cues for both upstream migrating adults and downstream migrating juvenile salmonids within the Delta. Option 3 is considered to be better for salmonids than either Option 1 or Option 2. There would be 7% more of the Delta available for potential habitat restoration/ enhancement under Option 3. The habitat opportunities under Option 3 would be the same as those under Option 2 but were not as great as those under Option 4.

Table 5-3 and 5-4 summarize the expected effects of implementing Option 3 under Scenarios A and B on important delta smelt stressors relative to base conditions.

Table 5-3. Summary of Expected Effects of Option 3 on Highly and Moderately Important Sacramento River Chinook Salmon Stressors

Applicable Criteria	Stressor[1]	Option Effects on Important Species Stressors Relative to Base Conditions	
		Scenario A	Scenario B
Highly Important Stressors			
2,3	Reduced staging and spawning habitat	Very low adverse effect	Very low adverse effect
2,3	Reduced rearing and outmigration habitat	Very low benefit	Very low benefit
1	Predation by non-natives	Low benefit	Low benefit
Moderately Important Stressors			
1	Harvest	No net effect	No net effect
1	Reduced genetic diversity/integrity	No net effect	No net effect
1,4	SWP/CVP entrainment	Moderate benefit	Moderate benefit
1,2	Exposure to toxics	Moderate adverse effect	Low adverse effect
2,3	Increased water temperature	No net effect	No net effect

Notes:
1. See Appendix C for descriptions of stressors, stressor impact mechanisms, and stressor effects.

Table 5-4. Summary of Expected Effects of Option 3 on Highly and Moderately Important Sacramento River Steelhead Stressors

Applicable Criteria	Stressor[1]	Option Effects on Important Species Stressors Relative to Base Conditions	
		Scenario A	Scenario B
Highly Important Stressors			
2,3	Reduced staging and spawning habitat	Very low adverse effect	Very low adverse effect
1,4	SWP/CVP entrainment	Moderate benefit	Moderate benefit
2,3	Reduced rearing and outmigration habitat	Very low benefit	Very low benefit
1	Predation by non-natives	Low benefit	Low benefit
Moderately Important Stressors			
1	Exposure to toxics	Moderate adverse effect	Low adverse effect
1	Reduced genetic diversity/ integrity	No net effect	No net effect
1	Harvest	No net effect	No net effect
2,3	Increased water temperature	No net effect	No net effect

Notes:
1. See Appendix C for descriptions of stressors, stressor impact mechanisms, and stressor effects.

5.1.3.1 Criterion #1. Relative degree to which the Option would reduce species mortality attributable to non-natural mortality sources, in order to enhance production (reproduction, growth, survival), abundance, and distribution for each of the covered fish species.

Overall, Option 3 would be expected to have a low benefit to Sacramento River salmonids by reducing sources of non-natural mortality.

Predation by Non-native Species

The ability to reduce the adverse impacts of populations of non-native predatory species under Option 3 is similar to that of Option 2 (see Option 2 for description). As with Option 2, there is a low increase in the ability to reduce the risk predation by non-natives under Option 3.

Entrainment

Juvenile Chinook salmon and steelhead would continue to be vulnerable to entrainment and salvage at the south delta export facilities to the extent that exports are made. The index of vulnerability to SWP and CVP salvage for juvenile salmon and steelhead indicates that the risk of salmonid salvage would substantial decrease under Option 3 relative to base conditions as a result of the reduction in exports from the south Delta and the ability to divert water from the Sacramento River through a fish screen. The diversion from the Sacramento River at Hood would be equipped with a state-of-the-art positive barrier fish screen that is expected to reduce the vulnerability of adult and juvenile salmon and steelhead to entrainment. The fish screen is expected to be designed in accordance to CDFG and NMFS design criteria for the protection of juvenile salmon and steelhead. The potential losses of juvenile salmonids to SWP and CVP exports are expected to be substantially lower than losses under either Options 1 or 2 and greater than predicted losses under Option 4.

Exposure to Toxics

Dilution of toxics was measured as flow at Rio Vista and total Delta inflow in March and April. Sacramento River flows at Rio Vista and total Delta inflows were generally moderately lower (20-30%) compared to base conditions under Option 3 during March and April for all water year types. These results suggest that Options 3 would reduce dilution flows of toxics in the Delta, resulting in a potential moderate increase the concentrations of toxics. Further, similar to Option 2, when San Joaquin River flow is conveyed directly to the central Delta, all toxics in the San Joaquin River would be transported directly to the central and western Delta, which is important juvenile salmon and steelhead foraging and rearing habitat and within the range of potential habitat restoration under Option 3 (Figure 1-4). Overall, Option 3 is expected to moderately increase exposure of salmonids to toxics.

5.1.3.2 Criterion #2. Relative degree to which the Option would provide water quality and flow conditions necessary to enhance production (reproduction, growth, survival), abundance, and distribution for each of the covered fish species.

Water quality changes that impact Sacramento River salmonids can be measured as differences in exposure to toxics, water temperature, and dissolved oxygen relative to base conditions.

Overall, a low adverse effect would be expected on flow and water quality conditions for Sacramento River salmonids under Option 3.

Exposure to Toxics

As discussed under Criterion #1, Option 3 is expected to moderately increase exposure of salmonids to toxics.

Rearing Habitat

The location of X_2 under Option 3 is expected to be 0.9 km upstream of the location of X_2 under base conditions. This would have a very low adverse effect on habitat quality of salmonids relative to base conditions. As discussed in the delta smelt section above, downstream flows are expected to be moderately lower under Option 3, thus reducing access to rearing habitat downstream.

SWP and CVP operations and the associated hydrologic conditions expected to occur within the Delta under Option 3 are not expected to result in dissolved oxygen depression greater than base conditions. The possible exception, would be the accumulation of high algal concentrations within the area of Old River and the western Delta resulting from increased nutrient concentrations, increased residence times, and reduced flushing. However, the barriers used to isolate Old River from Middle River (Figure 1-4) would be equipped with operable gates that, in the event of a dissolved oxygen depletion, could be opened to increase flushing and increase dissolved oxygen concentrations.

Access to Staging and Spawning Habitat

The effect of Option 3 on migration cues to Sacramento River salmonids would be similar to that of Option 2 when the Delta would be operated like Option 2. When the Delta would be operated like Option 4, migration cues would likely be reduced relative to base conditions due to water exports at Hood. Migration cues would likely be reduced in direct proportion to the export to inflow ratio. In general, attraction flows and migration cues would be expected to decline under Option 3.

5.1.3.3 Criterion #3. Relative degree to which the Option would increase habitat quality, quantity, accessibility, and diversity in order to enhance and sustain production (reproduction, growth, survival), abundance, and distribution; and to improve the resiliency of each of the covered species' populations to environmental change and variable hydrology.

Overall, Option 3 is expected to provide very low increases in quality, quantity, diversity, and accessibility of habitat for Sacramento River salmonids.

Rearing Habitat

The location of X_2 under Option 3 is expected to be 0.9 km upstream. This small change in rearing habitat would likely have a negligible effect on salmonids. Downstream transport to rearing habitat under Option 3 is expected to be lower, resulting in a low adverse effect to Sacramento River salmonids. The area of the Delta potentially available for restoration falls

primarily in rearing habitat for juvenile Sacramento River salmonids, such that there will be a moderate benefit to salmonids relative to base conditions. The potential opportunities to restore and enhance habitat for salmonids under Option 3 are the same as those describe for Option 2, are greater than those opportunities under Option 1, and are less than those opportunities under Option 4. Overall, Option 3 is expected to have a very low benefit on the quality, quantity, diversity, and accessibility of rearing and foraging habitat of juvenile Sacramento River Chinook salmon and steelhead.

Access to Staging and Spawning Habitat

As described in Criterion #2, there would be a low adverse effect of Option 3 on attraction flows and migration cues for Sacramento River salmonids. Overall, Option 3 is expected to cause a very low adverse effect on access of Sacramento River salmonids to staging and spawning habitat.

5.1.3.4 Criterion #4. Relative degree to which the Option would increase food quality, quantity, and accessibility (e.g., phytoplankton, zooplankton, macro-invertebrates, forage fish) to enhance production (reproduction, growth, survival) and abundance for each of the covered fish species.

Juvenile Chinook salmon and steelhead forage on a variety of macroinvertebrates (e.g., copepods, amphipods) and small fish during their residency within the Delta. The abundance of these prey species varies in response to a number of factors that include availability of nutrients, organic carbon, phytoplankton and zooplankton production. Reduced food availability or quality, however, are not identified as important stressors for Sacramento River salmonids. Consequently, benefits of increasing food quantity and quality under the Options would not be expected to result in a population level response relative to base conditions.

5.1.3.5 Criterion # 5. Relative degree to which the Option would reduce the abundance of non-native competitors and predators to increase native species production (reproduction, growth, survival), abundance and distribution for each of the covered fish species.

The potential for reducing non-native competitors and predators through restoration of aquatic habitat within the Delta under Option 3 is similar to Option 2 (see Option 2 for details). There are approximately 260,000 acres potentially available in the northern, central, and western Delta, or 35% of the entire statutory Delta, that could potentially support successful habitat restoration/enhancement. Therefore, Option 3 would be expected to provide a low benefit to Sacramento River salmonids by reducing the adverse impacts of non-native competitors and predators.

5.1.3.6 Criterion #6. Relative degree to which the Option improves ecosystem processes in the BDCP planning area to support aquatic and associated habitats.

Based on the proportion of the planning area suitable for restoration under Option 3 relative to the other Options and modeling results for hydraulic residence time (see Appendix H), Option 3 would be expected to provide a moderate beneficial improvement in ecosystem function relative to base conditions.

Under Option 3, Middle River would continue to serve as the water conveyance facility for freshwater supplies moving from the Sacramento River across the Delta to the export facilities located in the southern Delta. Movement of large volumes of water through Middle River would adversely affect hydraulic conditions, require dredging to increase conveyance capacity, and may require additional riprap to reduce levee scour and erosion. These conditions would degrade the quality of fishery habitat within Middle River. In contrast, the area adjacent to Old River and the central and western portion of the Delta would be improved by isolating these areas from the effects of export operations and by increasing residence times within the central Delta thereby reducing the export of nutrients, organic carbon, phytoplankton, and zooplankton from the Delta and increasing aquatic food production and availability. These changes would be expected to improve ecosystem processes within the central and western regions of the Delta when compared to base conditions.

5.1.3.7 Criterion #7. Relative degree to which the Option can be implemented within a timeframe to meet the near-term needs of each covered fish species (post BDCP authorization).

Habitat restoration under Option 3 can be initiated immediately following authorization of the BDCP and thus could be implemented in a manner that would meet the near term needs of Sacramento River salmonids. The implementation period for implementation of Option 3 is the same as the other Options.

5.1.4 San Joaquin River Salmonids

Overall, this Option will provide low benefit to San Joaquin River Chinook salmon and steelhead compared to base conditions. The potential opportunities for habitat restoration/enhancement under Option 3 would be possible in approximately 7% more of the Delta than under Option 1. The habitat opportunities under Option 3 were the same as those under Option 2 but were not as great as those under Option 4.

Tables 5-5 and 5-6 summarize the expected effects of implementing Option 3 under Scenarios A and B on important San Joaquin River salmonid stressors relative to base conditions.

Table 5-5. Summary of Expected Effects of Option 3 on Highly and Moderately Important San Joaquin River Chinook Salmon Stressors

Applicable Criteria	Stressor[1]	Option Effects on Important Species Stressors Relative to Base Conditions	
		Scenario A	Scenario B
Highly Important Stressors			
2,3	Reduced staging and spawning habitat	Very low benefit	Very low benefit
2,3	Reduced rearing and outmigration habitat	Low benefit	Low benefit
1,2	Exposure to toxics	Moderate adverse effect	Low adverse effect
1,5	Predation by non-natives	Low benefit	Low benefit

Table 5-5. Summary of Expected Effects of Option 3 on Highly and Moderately Important San Joaquin River Chinook Salmon Stressors (continued)

Applicable Criteria	Stressor[1]	Option Effects on Important Species Stressors Relative to Base Conditions	
		Scenario A	Scenario B
Moderately Important Stressors			
1	Reduced genetic diversity/ integrity	No net effect	No net effect
1	Harvest	No net effect	No net effect
1,4	SWP/CVP entrainment	Moderate benefit	Moderate benefit
2,3	Increased water temperature	No net effect	No net effect

Notes:
1. See Appendix C for descriptions of stressors, stressor impact mechanisms, and stressor effects.

Table 5-6. Summary of Expected Effects of Option 3 on Highly and Moderately Important San Joaquin River Steelhead Stressors

Applicable Criteria	Stressor[1]	Option Effects on Important Species Stressors Relative to Base Conditions	
		Scenario A	Scenario B
Highly Important Stressors			
2,3	Reduced staging and spawning habitat	Very low benefit	Very low benefit
2,3	Reduced rearing and outmigration habitat	Low benefit	Low benefit
1,2	Exposure to toxics	Moderate adverse effect	Low adverse effect
1	Reduced genetic diversity/ integrity	No net effect	No net effect
1,5	Predation by non-natives	Low benefit	Low benefit
Moderately Important Stressors			
1,4	SWP/CVP entrainment	Moderate benefit	Moderate benefit
1	Harvest	No net effect	No net effect
2,3	Increased water temperature	No net effect	No net effect

Notes:
1. See Appendix C for descriptions of stressors, stressor impact mechanisms, and stressor effects.

5.1.4.1 Criterion #1. Relative degree to which the Option would reduce species mortality attributable to non-natural mortality sources, in order to enhance production (reproduction, growth, survival), abundance, and distribution for each of the covered fish species.

Overall, Option 3 would be expected to have moderate benefit to San Joaquin River salmonids by reducing sources of non-natural mortality.

Predation by Non-native Species

The potential reducing predation risk by non-native species under Option 3 would be similar to Option 2 describe above. Overall, the potential for reduced predation risk is expected to be moderate.

Entrainment

Entrainment risk would be eliminated for San Joaquin River salmonids under Option 3 relative to base conditions for San Joaquin River salmonids when water is exported according to the Option 4 configuration. Under this condition water would be diverted from the Sacramento River through a positive barrier fish screen. San Joaquin River salmonids would not be present in the vicinity of the diversion location. When water is exported according to the Option 2 configuration, San Joaquin River fish from the Mokelumne and Cosumnes rivers would experience substantially increased entrainment relative to base conditions, whereas those from other San Joaquin tributaries would be less vulnerable to entrainment than under base conditions. Overall, the vulnerability index indicates that Option 3 is expected to cause a moderate reduction in entrainment of San Joaquin River.

Exposure to Toxics

As discussed below under Criterion #2, Option 3 would cause a moderate increase in exposure of San Joaquin River salmonids to toxics.

5.1.4.2 Criterion #2. Relative degree to which the Option would provide water quality and flow conditions necessary to enhance production (reproduction, growth, survival), abundance, and distribution for each of the covered fish species.

Overall, it is expected that Option 3 would provide a very low adverse effect to water quality and flow conditions for San Joaquin River salmonids. However, this finding is based, in part, on model output that assumes diversions would occur preferentially at Hood. By having two diversion locations, there would be potential to modify the effects of this Option on water quality and flow conditions.

Exposure to Toxics

Sacramento River flows at Rio Vista and total Delta inflow under Option 3 would be lower than base conditions in both months and in all water year types (see Appendices F and H). In addition, the configuration of barriers and the siphon to pass San Joaquin River water into the central Delta (Figure 1-3) would potentially increase concentrations, residence time, exposure to elevated toxic concentrations, and reduce dilution of higher concentrations of toxics and salinity originating within the San Joaquin River watershed. The San Joaquin River water would not be diluted with Delta water before it enters the central Delta. As a result, this relocation would likely have moderate adverse effects on exposure of San Joaquin River salmonids to toxics.

Rearing Habitat

The location of X_2 under Option 3 is expected to be 0.9 km upstream of the location of X_2 under base conditions. This would have a very low adverse effect on habitat quality of salmonids relative to base conditions. As discussed above, downstream flows are expected to be moderately lower under Option 3, thus reducing access to rearing habitat downstream. A reduction in flows passing through the Delta under Option 3 has the potential to contribute to reduced juvenile salmonid survival, however, the magnitude of potential change is unknown.

SWP and CVP operations and the associated hydrologic conditions expected to occur within the Delta under Option 3 are expected to cause an increase in localized dissolved oxygen depressions relative to baseline conditions. By diverting the San Joaquin River at Old River, flushing flows in the Stockton ship channel would likely be reduced, causing a greater extent of localized depressions of dissolved oxygen levels than currently exist. Further, the accumulation of high algal concentrations within the area of Old River and the western Delta resulting from increased nutrient loading, increased residence times, and reduced flushing. The barriers used to isolate Old River from Middle River (Figure 1-3) would be equipped with operable gates that, in the event of a dissolved oxygen depletion, could be opened to increase flushing and increase dissolved oxygen concentrations. The extent to which dissolved oxygen sags will occur under this Option is largely uncertain.

Access to Staging and Spawning Habitat

The passage of San Joaquin River flow downstream into the central Delta would be expected to provide a net positive downstream flow and may improve migration cues for juvenile movement and improved attraction flows for adult upstream migration when compared to base conditions. However, Option 3 would potentially reduce migratory cues for the large portion of San Joaquin River salmonids that originate from the Cosumnes and Mokelumne rivers in the event that Middle river is used to convey large flows across the Delta to the south Delta export facilities. To the extent that water diversions occur under Option 3 from the Sacramento River at Hood operations under Option 3 would be expected to result in substantially improve hydrodynamic conditions affecting adult and juvenile attraction and migration when compared to base conditions. Overall, because exports would likely be diverted preferentially from Hood, there would likely be a low positive effect on migratory cues for San Joaquin River salmonids under Option 3.

5.1.4.3 Criterion #3. Relative degree to which the Option would increase habitat quality, quantity, accessibility, and diversity in order to enhance and sustain production (reproduction, growth, survival), abundance, and distribution; and to improve the resiliency of each of the covered species' populations to environmental change and variable hydrology.

Overall, Option 3 is expected to provide a low increase in habitat availability and quality.

Rearing Habitat

The small change in X_2 under Option 3 would likely have a negligible effect on rearing habitat conditions for salmonids. Downstream transport to rearing habitat under Option 3 is not

expected to change under Option 3 because San Joaquin flow standards (D-1641 and VAMP) were set as assumptions in the hydrologic model. The area of the Delta potentially available for restoration falls primarily in rearing habitat for juvenile San Joaquin River salmonids, such that there will be a moderate benefit to salmonids relative to base conditions. However, San Joaquin River flows, which carry substantially higher salinity and toxic concentrations, would discharge into this restoration area. Therefore, the effectiveness of the restoration may be limited. Overall, Option 3 is expected to have a low benefit on the quality, quantity, diversity, and accessibility of rearing and foraging habitat of juvenile River Chinook salmon and steelhead.

Access to Staging and Spawning Habitat

As discussed in Criterion #2, Option 3 would likely have a very low positive effect on migratory cues for San Joaquin River salmonids.

Overall, Option 3 is expected to provide a low increase in habitat availability and quality.

5.1.4.4 Criterion #4. Relative degree to which the Option would increase food quality, quantity, and accessibility (e.g., phytoplankton, zooplankton, macro-invertebrates, forage fish) to enhance production (reproduction, growth, survival) and abundance for each of the covered fish species.

Juvenile Chinook salmon and steelhead forage on a variety of macroinvertebrates (e.g., copepods, amphipods) and small fish during their residency within the Delta. The abundance of these prey species varies in response to a number of factors that include availability of nutrients, organic carbon, phytoplankton and zooplankton production. Reduced food availability or quality, however, are not identified as important stressors for Sacramento River salmonids. Consequently, benefits of increasing food quantity and quality under the Options would not be expected to result in a population level response relative to base conditions.

5.1.4.5 Criterion #5. Relative degree to which the Option would reduce the abundance of non-native competitors and predators to increase native species production (reproduction, growth, survival), abundance and distribution for each of the covered fish species.

The potential for reducing the adverse impacts of non-native competitors and predators through restoration of aquatic habitat within the Delta under Option 3 is similar to Option 2 (see Option 2 for details). Habitat restoration could potentially occur within approximately 35% of the planning area in the northern, central, and western Delta. Therefore, Option 3 would be expected to provide a moderate benefit to San Joaquin River salmonids by reducing non-native competitors and predators.

5.1.4.6 Criterion #6. Relative degree to which the Option improves ecosystem processes in the BDCP planning area to support aquatic and associated habitats.

Based on the proportion of the planning area suitable for restoration under Option 3 relative to the other Options and modeling results for hydraulic residence time (see Appendix H), Option 3 would be expected to provide a moderate beneficial improvement in ecosystem function relative to base conditions.

Under Option 3, Middle River would continue to serve as the water conveyance facility for freshwater supplies moving from the Sacramento River across the Delta to the export facilities located in the southern Delta. Movement of large volumes of water through Middle River would adversely affect hydraulic conditions, require dredging to increase conveyance capacity, and may require additional riprap to reduce levee scour and erosion. These conditions would degrade the quality of fishery habitat within Middle River. In contrast, the area adjacent to Old River and the central and western portion of the Delta would be improved by isolating these areas from the effects of export operations and by increasing residence times within the central Delta thereby reducing the export of nutrients, organic carbon, phytoplankton, and zooplankton from the Delta and increasing aquatic food production and availability. These changes would be expected to improve ecosystem processes within the central and western regions of the Delta when compared to base conditions.

5.1.4.7 Criterion #7. Relative degree to which the Option can be implemented within a timeframe to meet the near-term needs of each covered fish species (post BDCP authorization).

Habitat restoration under Option 3 can be initiated immediately following authorization of the BDCP and thus could be implemented in a manner that would meet the near term needs of San Joaquin River salmonids. The implementation period for implementation of Option 3 is the same as the other Options.

5.1.5 Green and White Sturgeon

Based on the evaluation presented below of the expected performance of Option 3 for addressing important green and white sturgeon stressors, Option 3 would be expected to have a low beneficial effect on green and white sturgeon production, distribution, and abundance relative to base conditions when operated to meet water supply objectives (Scenario A). If water supply exports were reduced (Scenario B), Option 3 would be expected to provide a similar level of benefit for sturgeon production, distribution, and abundance relative to base conditions. For green sturgeon, Option 3 would be expected to provide the same level of benefits as Option 2, and lower benefits than under Option 1, and lower benefits than under Option 4. For white sturgeon, Option 3 would be expected to provide higher benefits than under Option 1, the same benefits as under Option 2, and lower benefits than under Option 4.

Stressors that affect sturgeon are presented in Figures 2-7 and 2-8 and are described in Appendix C. The effect of these stressors on the green and white sturgeon populations vary among years in response to environmental conditions (e.g., seasonal hydrology) and may also interact with each other in additive or synergistic ways. The effects of these stressors include both the incremental contribution of a stressor to the population as well as the cumulative effects of multiple stressors over time. The assessment of Option 3 evaluates the degree to which Option 3 would be expected to address these stressors.

Tables 5-7 and 5-8, respectively, summarize the expected effects of implementing Option 1 under Scenarios A and B on important sturgeon stressors relative to base conditions.

Table 5-7. Summary of Expected Effects of Option 1 on Highly and Moderately Important Green Sturgeon Stressors

Stressors[1]	Applicable Criteria	Option Effects on Important Species Stressors Relative to Base Conditions	
		Scenario A	Scenario B
Highly Important Stressors			
Reduced spawning habitat	3	No net effect	No net effect
Exposure to toxics	1,2,3	Moderate adverse effect	Moderate adverse effect
Harvest	1	No net effect	No net effect
Moderately Important Stressors			
Reduced rearing habitat	1,2,3	Low benefit	Low benefit
Increased water temperature (upstream)	1,2,3	No net effect	No net effect
Predation	1,3	No net effect	No net effect
Reduced turbidity	1,2,3	No net effect	No net effect

Notes:
1. See Appendix C for descriptions of stressors, stressor impact mechanisms, and stressor effects.

Table 5-8. Summary of Expected Effects of Option 1 on Highly and Moderately Important White Sturgeon Stressors

Stressors[1]	Applicable Criteria	Option Effects on Important Species Stressors Relative to Base Conditions	
		Scenario A	Scenario B
Highly Important Stressors			
Harvest	1	No net effect	No net effect
Reduced spawning habitat	3	No net effect	No net effect
Exposure to toxics	1,2,3	Moderate adverse effect	Moderate adverse effect
Moderately Important Stressors			
Reduced rearing habitat	1,2,3	Low benefit	Low benefit
Increased water temperature (upstream)	1,2,3	No net effect	No net effect
Predation	1,3	No net effect	No net effect
Reduced turbidity	1,2,3	No net effect	No net effect

Notes:
1. See Appendix C for descriptions of stressors, stressor impact mechanisms, and stressor effects.

Harvest, reduced spawning habitat, predation, reduced turbidity, and increased water temperatures are not important stressors that would be affected by or affected differently (i.e., harvest, reduced spawning habitat) under the Options and, therefore, are not described in the criteria evaluations below (see Table 2-3 and Appendix C). These stressors could only be

addressed through changes in regulation and law enforcement (for harvest) or through conservation actions implemented outside of the planning area. Any effects within the planning area of the Options on the non-harvest stressors described above would not be expected to have any benefits to sturgeon at the population level. As described in Table 2-3, the ability to address harvest and reduced spawning habitat within the planning area would be the same among the Options. Consequently, these stressors are initially identified under the applicable criteria below, but are not evaluated under the criteria.

5.1.5.1 Criterion #1. Relative degree to which the Option would reduce species mortality attributable to non-natural mortality sources, in order to enhance production (reproduction, growth, survival), abundance, and distribution for each of the covered fish species.

Based on the following evaluation of Option 3 effects on applicable green and white sturgeon stressors, Option 3 is expected to provide no change from base conditions in the risk of non-natural mortality of sturgeon.

Exposure to Toxics

Exposure of green and white sturgeon to toxic substances can result in mortality of sturgeon. The effects of Option 3 on exposure to toxics are evaluated under Criteria #2 and #4 below. As described in the Criteria #2 and #4 evaluations, Option 3 would be expected to provide a moderate adverse increase for exposure of green and white sturgeon to toxics.

5.1.5.2 Criterion #2. Relative degree to which the Option would provide water quality and flow conditions necessary to enhance production (reproduction, growth, survival), abundance, and distribution for each of the covered fish species.

Based on the following evaluation of Option 3 effects on applicable green and white sturgeon stressors, Option 3 is expected to provide a very low adverse effect for water quality and flow conditions that support green and white sturgeon relative to base conditions.

Exposure to Toxics

Based on how Option 3 would be expected to affect Sacramento River inflow and total Delta inflows relative to modeling results for base conditions and the Options, dilution flows under Option 3 would be lower than under base conditions and could have a moderate adverse affect by increasing the exposure of sturgeon to toxics (see Appendices F and H).

Reduced Rearing Habitat

Based on how Option 3 would be expected to affect the X_2 location in April relative to X_2 modeling results for base conditions and the Options, X_2 position would move upstream relative to base conditions (see Appendices F and H), indicating that the extent of available rearing habitat could be reduced relative to base conditions. In addition, Option 3 would be expected to improve westerly flows through the central Delta as a migration cue for both juvenile and adult sturgeon migration. The changes in hydrologic conditions expected to occur under Option 3 on Middle River would be expected to degrade habitat conditions and

hydraulic migration cues for adult and juvenile sturgeon inhabiting the eastern region of the Delta to the extent that exports are made from the south Delta under Option 3. The effect of these changed hydraulic conditions is unknown, because the frequency of occurrence of green or white sturgeon juveniles and adults within the eastern region of the Delta is unknown. To the extent that exports are made from the Sacramento River under Option 3 flow patterns in Delta channels would be expected to improve for juvenile and adult sturgeon.

5.1.5.3 Criterion #3 Relative degree to which the Option would increase habitat quality, quantity, accessibility, and diversity in order to enhance and sustain production (reproduction, growth, survival), abundance, and distribution; and to improve the resiliency of each of the covered species' populations to environmental change and variable hydrology.

Within the planning area, green and white sturgeon habitat conditions are governed by hydrodynamic conditions and the extent and quality of habitat within the planning area. Under Option 3, these conditions relative to base conditions would be affected by the conveyance configuration of Option 3 and the opportunities for restoration of physical habitat that could be sited within Suisun Bay and Marsh and within the planning area in the north, central, and west Delta, which represents approximately 35% of the planning area. A reduction in the magnitude and frequency of water diversions from the south Delta under Option 3 would improve channel flows and habitat conditions within the Delta for sturgeon.

Based on the following evaluation of Option 3 effects on applicable green and white sturgeon stressors, Option 3 is expected to provide low habitat benefits for sturgeon relative to base conditions.

Exposure to Toxics

As described under Criterion #2 above, Option 3 could have a low adverse effect on the risk for exposure of sturgeon to toxics relative to base conditions. A major source for bioaccumulation of selenium in sturgeon is consumption of non-native *Corbula* and *Corbicula*, which capture selenium from Delta waters. Restoration of aquatic shallow subtidal and intertidal habitats could create conditions that favor the production of alternative prey (e.g., bay shrimp) that reduce the risk of bioaccumulation of materials such as selenium for juvenile and adult sturgeon. The potential success of reducing the risk of toxics on sturgeon through habitat improvements and increased production of alternative prey resources is uncertain. Under Option 3, habitat could potentially be restored within Suisun Bay and Marsh and approximately 35% of the Delta to provide high quality aquatic habitat under this Option (Figure 1-4), which encompasses a larger proportion of the white sturgeon's rearing range than restoration that could be implemented under Option 1, the same proportion as under Option 2, and a smaller proportion than under Option 4. Because the green sturgeon is not known to occupy the San Joaquin River watershed but do occur within the central Delta, restoration opportunities would be the same under Option 3 as under Option 2, but less than under Option 4, which includes restoration opportunities in the east Delta north of the San Joaquin River. Consequently, relative to base conditions and the other Options, Option 3 would be expected to provide a low benefit for improving green and white sturgeon rearing habitat.

Reduced Rearing Habitat

The primary impact mechanism believed to affect the extent of rearing habitat and rearing habitat conditions is the reclamation of historical aquatic subtidal and intertidal habitats and channelization of river channels. Under Option 3, habitat could potentially be restored within Suisun Bay and Marsh and approximately 35% of the Delta to provide high quality aquatic habitat under this Option (Figure 1-4), which encompasses a larger proportion of the white sturgeon's rearing range than restoration that could be implemented under Option 1, the same proportion as under Option 2, and a smaller proportion than under Option 4. Because the green sturgeon is not known to occupy the San Joaquin River watershed but do occur within the central Delta, restoration opportunities would be the same under Option 3 as under Option 2, but less than under Option 4, which includes restoration opportunities in the east Delta north of the San Joaquin River. Consequently, relative to base conditions and the other Options, Option 3 would be expected to provide a low benefit for green and white sturgeon rearing habitat.

5.1.5.4 Criterion #4. Relative degree to which the Option would increase food quality, quantity, and accessibility (e.g., phytoplankton, zooplankton, macro-invertebrates, forage fish) to enhance production (reproduction, growth, survival) and abundance for each of the covered fish species.

Based on the following evaluation of Option 3 effects on applicable green and white stressors, Option 3 is expected to provide low food supply benefits for green and white sturgeon relative to base conditions.

Exposure to Toxics

As described under Criterion #3 above, restoration of rearing habitat could reduce the relative importance of non-native *Corbula* and *Corbicula* thus improving the quality of food for sturgeon by reducing their exposure to selenium. Relative to base conditions and the other Options, Option 3 would be expected to provide low benefits for green and white sturgeon rearing habitat.

5.1.5.5 Criterion #5. Relative degree to which the Option would reduce the abundance of non-native competitors and predators to increase native species production (reproduction, growth, survival), abundance and distribution for each of the covered fish species.

Predation in the form of illegal and legal harvest would not be changed under any of the Options from base conditions.

5.1.5.6 Criterion #6. Relative degree to which the Option improves ecosystem processes in the BDCP planning area to support aquatic and associated habitats.

Based on the proportion of the planning area potentially available for restoration under Option 3 relative to the other Options and modeling results for hydraulic residence time (see Appendix H), Option 3 would be expected to provide a moderate beneficial improvement in ecosystem function relative to base conditions. These benefits to ecosystem processes under Option 3 are also linked to the ability to divert water from the Sacramento River and improve hydrodynamic flow patterns within the Delta.

Under the range of operations and the potential opportunities to restore/enhance high quality aquatic habitat within the Delta habitat, the effectiveness of Option 3 in improving ecosystem processes is considered to be moderate. Middle River would continue to serve as the water conveyance facility for freshwater supplies moving from the Sacramento River across the Delta to the export facilities located in the southern Delta. Movement of large volumes of water through Middle River would adversely affect hydraulic conditions, require dredging to increase conveyance capacity, and may require additional riprap to reduce levee scour and erosion. These conditions would degrade the quality of fishery habitat within Middle River. In contrast, the area adjacent to Old River and the central and western portion of the Delta would be improved by isolating these areas from the effects of export operations and by increasing residence times within the central Delta thereby reducing the export of nutrients, organic carbon, phytoplankton, and zooplankton from the Delta and increasing aquatic food production and availability. These changes would be expected to improve ecosystem processes within the central and western regions of the Delta when compared to base conditions. In addition, the ability to divert water directly from the Sacramento River at Hood while reducing the export operations within the south Delta would be expected to substantially improve the hydrodynamics of the Delta and improve the quality of habitat available for juvenile and adult sturgeon. Under these operating conditions Option 3 offers the opportunity to improve the processes affecting habitat conditions within the Delta (e.g., providing net westerly flows, reducing or eliminating reverse flow conditions, etc.). These potential changes to the estuarine processes within the Delta are expected to benefit sturgeon and other species. It is uncertain, however, if the discharge of low quality San Joaquin River water into the central Delta would impair ecosystem processes.

5.1.5.7 Criterion #7. Relative degree to which the Option can be implemented within a timeframe to meet the near-term needs of each covered fish species (post BDCP authorization).

In the near-term, until construction of Option 3 conveyance features and facilities is completed, Option would use the existing conveyance facilities to meet water supply objectives. As for Option 1, implementation of physical habitat restoration under Option 3 in the north and west Delta can be initiated immediately following authorization of the BDCP and thus could be implemented in a manner that would meet the near-term needs of green and white sturgeon.

5.1.6 Splittail

Based on the evaluation presented below of the expected performance of Option 3 for addressing important splittail stressors, Option 3 would be expected to have a moderate beneficial effect on splittail production, distribution, and abundance relative to base conditions when operated to meet water supply objectives (Scenario A). If water supply exports were reduced (Scenario B), Option 3 would also be expected to provide a moderate beneficial effect on splittail production, distribution, and abundance relative to base conditions. Option 3 would be expected to provide a greater level of benefit for splittail than Options 1 and 2, but a lower level of benefit compared to Option 4.

Table 5-9 summarizes the expected effects of implementing Option 3 under Scenarios A and B on important splittail stressors relative to base conditions.

Table 5-9. Summary of Expected Effects of Option 3 on Highly and Moderately Important Splittail Stressors

Applicable Criteria	Stressor[1]	Option Effects on Important Species Stressors Relative to Base Conditions	
		Scenario A	Scenario B
Highly Important Stressors			
2,3	Reduced juvenile rearing/adult habitat	Moderate benefit	Moderate benefit
2,3	Reduced spawning/larval rearing habitat	Moderate benefit	Moderate benefit
1,4	Reduced food	Moderate benefit	High benefit
1,2	Exposure to toxics	Moderate adverse effect	Low adverse effect
Moderately Important Stressors			
1,5	Predation	Moderate benefit	Moderate benefit
1,4	SWP/CVP entrainment	High benefit	High benefit
1	Harvest	No net effect	No net effect

Notes:

1. See Appendix C for descriptions of stressors, stressor impact mechanisms, and stressor effects.
2. Although it is recognized that the risk of entrainment at the SWP and CVP export facilities may, in some years, be a high level stressor to splittail, and in some years represents a very low level stressor to splittail, for purposes of the analysis the risk of delta smelt entrainment under each of the Options has been characterized, on average, as a moderate level stressor to the population.

5.1.6.1 Criterion #1. Relative degree to which the Option would reduce species mortality attributable to non-natural mortality sources, in order to enhance production (reproduction, growth, survival), abundance, and distribution for each of the covered fish species.

Based on the following evaluation of Option 3 effects on applicable splittail stressors, Option 3 is expected to provide moderate benefits for splittail by reducing the effects of non-natural sources of mortality relative to base conditions.

Reduced Food Availability

Habitat conditions can affect the availability and quality of splittail food. The effects of Option 3 on splittail food availability are evaluated under Criterion #4 below. As described in the Criterion #4 evaluation, Option 3 would be expected to provide a moderate beneficial effect on food supply for the splittail relative to base conditions.

Exposure to Toxics

The effects of Option 3 on exposure to toxics are evaluated under Criterion #2 below. As described in the Criterion #2 evaluation, Option 3 would be expected to continue to provide lower dilution flows relative base conditions and could increase exposure to toxics discharged from the San Joaquin River into the central Delta, which could have a moderate adverse effect

on splittail. It is uncertain, however, if the potential increase in concentrations of toxics in the central Delta would adversely affect splittail.

Predation

Under Option 3, approximately 35% of the Delta would potentially be available for restoration/enhancement (Figure 1-4), which, if designed properly, would reduce predation risk by non-natives. This entire area would be located within the geographic range of splittail within the northern, western, and central regions of the Delta. The proportion of the planning area within which habitat could potentially be implemented is greater than under Option 1, the same as under Option 2, but less than under Option 4. Habitat restoration under Option 3 would be expected to provide a moderate benefit for potentially reducing the adverse impacts of predation relative to base conditions and the other Options. However, there is a high degree of uncertainty regarding the biological response of splittail, other native fish and macroinvertebrate species, and non-native species to large-scale habitat restoration/ enhancement within the Delta.

Entrainment by CVP/SWP Facilities

Under operations of Option 3, juvenile splittail emigrating from the San Joaquin River would be transported downstream into Old River and the central Delta. As a result, the vulnerability of San Joaquin River juvenile splittail to entrainment or salvage at the SWP or CVP export facilities would be greatly reduced. San Joaquin River splittail could be exposed to a risk for entrainment during periods of high reverse flow in Middle River and the lower San Joaquin River during periods when diversions from the south Delta export facilities are high. The configuration of barriers and increased flows in Middle River under Option 3 would, however, be expected to contribute to a substantial increase in mortality of juvenile splittail emigrating from other east side tributaries such as the Mokelumne and Cosumnes rivers. These juvenile splittail would be expected to migrate downstream within Middle River and have increased vulnerability to entrainment and salvage at the SWP and CVP export facilities. Risk for entrainment into Middle River, however, would be increased during periods of reverse flow in the San Joaquin River, but would be expected to be lower than under Option 2 which would pump water from Middle River through the siphon. Risk for entrainment of splittail at the Hood intake facility would be minimal because the intake would be equipped with a positive barrier fish screen that would be expected to be highly effective in reducing the vulnerability of juvenile and adult splittail to entrainment. The relative magnitude of potential benefits under Option 3 to reducing splittail entrainment would vary depending on the balance of exports that would be made from the Sacramento River at Hood relative to the exports from the south Delta. Option 3 would be expected to provide a high benefit for splittail by reducing the likelihood for entrainment of splittail relative to base conditions because:

- a gravity fed siphon would be employed,
- the amount of water pumped from the south Delta would be substantially reduced,
- there is flexibility to only export water from the south Delta when splittail would be least vulnerable to entrainment, and
- there is minimal risk for entrainment of splittail at the Hood intake facility.

5.1.6.2 Criterion #2. Relative degree to which the Option would provide water quality and flow conditions necessary to enhance production (reproduction, growth, survival), abundance, and distribution for each of the covered fish species.

Based on the following evaluation of Option 3 effects on applicable splittail stressors, Option 3 is expected to have a low adverse effect on water quality and flow conditions that support splittail relative to base conditions.

Exposure to Toxics

Dilution flows from the Sacramento River and other Delta tributaries are one way of reducing concentrations of toxics and their effect on juvenile and adult splittail. Modeling results indicate that Option 3 would be expected to reduce dilution flows relative to base conditions, thus potentially increasing concentrations of toxics (see Appendices F and H). As described for Option 2, there is also the potential for the physical configuration of Option 3 to cause an increase in toxic loading in the area of the central Delta that is available for restoration (Figure 1-4). The configuration of barriers and the siphon to transport San Joaquin River water into the central Delta would potentially increase toxic loading to the central Delta by reducing the dilution of higher concentrations of toxics and salinity originating within the San Joaquin River watershed. Although the effects of toxics on splittail are uncertain, Option 3 has the potential for having a moderate adverse effect on splittail by increasing the exposure of rearing and foraging splittail to higher concentrations of toxics.

Reduced Rearing Habitat

Sacramento River inflows during March and April under Option 3 that facilitate the downstream movement of juvenile splittail are expected to be lower relative to base conditions. Expected changes in peak Delta inflows during January through March indicate that Option 3 would have a lower probability of floodplain inundation relative to base conditions in wetter years (see Appendices F and H). The potential restoration of rearing habitats as described under Criterion #3, however, would be expected to improve rearing habitat conditions. Consequently, overall Option 3 would be expected to have moderate beneficial effects on rearing habitat conditions relative to base conditions.

Reduced Spawning/Larval Rearing Habitat

Expected changes in peak Delta inflows during January through March indicate that, under Option 3, there would be a lower probability of floodplain inundation during wetter years relative to base conditions but a similar probability under drier water years (see Appendices F and H). The potential restoration of spawning/larval rearing habitats as described under Criterion #3, however, would be expected to improve spawning/larval rearing habitat conditions. Consequently, overall Option 3 would be expected to have moderate beneficial effects on rearing habitat conditions relative to base conditions.

5.1.6.3 Criterion #3. Relative degree to which the Option would increase habitat quality, quantity, accessibility, and diversity in order to enhance and sustain production (reproduction, growth, survival), abundance, and distribution; and to improve the resiliency of each of the covered species' populations to environmental change and variable hydrology.

Based on the following evaluation of Option 3 effects on applicable splittail stressors, Option 3 is expected to provide moderate benefits relative to habitat conditions for the splittail.

Within the planning area, splittail habitat conditions are governed by hydrodynamic conditions and the extent and quality of habitat. Under Option 3, these conditions relative to base conditions would be affected by the conveyance configuration of Option 3 and the opportunities for restoration of physical habitat that could be sited within Suisun Bay and Marsh and within 35% of the planning area in the north, central, and west Delta.

Reduced Rearing and Spawning Habitat

Under Option 3, habitat could be restored within Suisun Bay and Marsh and approximately 35% of the Delta to provide high quality shallow aquatic subtidal and intertidal habitat (Figure 1-4), which encompasses a larger proportion of the splittail spawning and rearing range than restoration that could be implemented under Option 1, the same proportion as under Option 2, and a smaller proportion than under Option 4. In addition, substantial increases in hydraulic residence time under Option 3 also provide for lower velocity habitats that are expected to be more suitable for splittail relative to base conditions. Consequently, relative to base conditions and the other Options, Option 3 would be expected to provide a moderate benefit for splittail rearing and spawning habitat.

Reduced Food Availability

Habitat conditions can affect the availability and quality of splittail food. The effects of Option 3 on splittail food availability are evaluated under Criterion #4 below. As described in the Criterion #4 evaluation, Option 3 would be expected to provide a moderate beneficial effect on food supply for the splittail relative to base conditions.

5.1.6.4 Criterion #4. Relative degree to which the Option would increase food quality, quantity, and accessibility (e.g., phytoplankton, zooplankton, macro-invertebrates, forage fish) to enhance production (reproduction, growth, survival) and abundance for each of the covered fish species.

Overall, Option 3 would be expected to provide moderate benefits for improving food supply for splittail.

Reduced Food Availability

Option 3 could decrease the frequency, duration, and extent of seasonally inundated floodplain habitat within the Sacramento or San Joaquin Rivers, which could reduce food availability in those areas in some years. Hydraulic residence would be substantially increased in the central Delta and would be expected to substantially increase phytoplankton, zooplankton, and

macroinvertebrate production within the central Delta relative to base conditions. Restoration of shallow subtidal and intertidal habitats under Option 3 would also be expected to improve food supply. Consequently, Option 3 would be expected to provide a moderate benefit for splittail food supply.

The habitat restoration that would be implemented under Option 3 would all be located within the geographic range of splittail and could create conditions that disfavor non-native species that indirectly or directly affect food abundance (e.g., overbite clam (*Corbula*), threadfin shad), thereby improving food availability for splittail relative to base conditions (Figure 1-4). The potential opportunity for habitat restoration is expected to improve food availability relative to Option 1, would be the same relative to Option 2, and less than under Option 4.

Option 3 would be expected to provide a moderate beneficial increase in food availability by reducing the export of nutrients and organic material that support primary and secondary production by reducing SWP/CVP exports from the south Delta. In addition, under Option 3, water with high nutrient loads from the San Joaquin River would no longer be subject to the same level of exports as under base conditions and these waters would be conveyed downstream into the central region of the Delta where increased nutrient loads, in combination with increased residence times, would be expected to stimulate phytoplankton and zooplankton production.

5.1.6.5 Criterion #5. Relative degree to which the Option would reduce the abundance of non-native competitors and predators to increase native species production (reproduction, growth, survival), abundance and distribution for each of the covered fish species.

Based on the following evaluation of Option 3 effects on applicable splittail stressors, Option 3 is expected to provide moderate benefits for splittail relative to the abundance of non-native competitors and predators.

Option 3 could reduce the effects of non-native competitors and predators on splittail primarily through restoration of intertidal and shallow subtidal aquatic habitats in the north, west, and central Delta. For reasons described above, Option 3 would be expected to provide a moderate beneficial effect by reducing the impacts of populations of non-native food competitors relative to base conditions. Additionally, the operable barriers along Middle River provide some opportunity under Option 3 to adaptively manage Delta hydrodynamics to create hydrodynamic conditions that favor the splittail and disfavor predators and competitors to improve conditions for the splittail. Although the ability to control non-native species by varying hydrodynamic conditions in the Delta is uncertain, Option 3 provides the greatest opportunity for doing so among the Options.

5.1.6.6 Criterion #6. Relative degree to which the Option improves ecosystem processes in the BDCP planning area to support aquatic and associated habitats.

Based on the proportion of the planning area potentially available and suitable for restoration under Option 3 relative to the other Options and modeling results for hydraulic residence time (see Appendix H), Option 3 would be expected to provide a moderate beneficial improvement in ecosystem function relative to base conditions.

Under the range of operations and the potential opportunities to restore/enhance high quality aquatic habitat within the Delta habitat, the effectiveness of Option 3 in improving ecosystem processes is considered to be moderate. Middle River would continue to serve as the water conveyance facility for freshwater supplies moving from the Sacramento River across the Delta to the export facilities located in the southern Delta. Movement of large volumes of water through Middle River would adversely affect hydraulic conditions, require dredging to increase conveyance capacity, and may require additional riprap to reduce levee scour and erosion. These conditions would degrade the quality of fishery habitat within Middle River. In contrast, the area adjacent to Old River and the central and western portion of the Delta would be improved by isolating these areas from the effects of export operations and by increasing residence times within the central Delta thereby reducing the export of nutrients, organic carbon, phytoplankton, and zooplankton from the Delta and increasing aquatic food production and availability. These changes would be expected to improve ecosystem processes within the central and western regions of the Delta when compared to base conditions. In addition, the ability to divert water directly from the Sacramento River at Hood while reducing the export operations within the south Delta would be expected to substantially improve the hydrodynamics of the Delta and improve the quality of habitat available for juvenile and adult splittail. Under these operating conditions Option 3 offers the opportunity to improve the processes affecting habitat conditions within the Delta (e.g., providing net westerly flows, reducing or eliminating reverse flow conditions, etc.). These potential changes to the estuarine processes within the Delta are expected to benefit splittail and other species. It is uncertain, however, if the discharge of low quality San Joaquin River water into the central Delta would impair ecosystem processes.

5.1.6.7 Criterion #7. Relative degree to which the Option can be implemented within a timeframe to meet the near-term needs of each covered fish species (post BDCP authorization).

In the near-term, until construction of Option 3 conveyance features and facilities is completed, Option 3 would use the existing conveyance facilities to meet water supply objectives. As for Option 1, implementation of physical habitat restoration under Option 3 in the north and west Delta can be initiated immediately following authorization of the BDCP and thus could be implemented in a manner that would meet the near-term needs of splittail.

5.2 PLANNING CRITERIA

5.2.1.1 Criterion #8: Relative degree to which the Option allows covered activities to be implemented in a way that meets the goals and purposes of those activities

Under Option 3, the ability to achieve the water delivery reliability and facility operation goals of the CVP/SWP is expected to exceed current conditions and all other Options (Figure 3-1).

Model simulations undertaken for this evaluation indicate the potential for increased CVP/SWP exports in the range of 70 to 500 TAF/YR depending on the level of Rio Vista flow requirements, X2 objectives, salinity requirements, and Middle River and QWEST flow restrictions. The ability to meet the goals of this criterion is significantly enhanced by the use of a dual diversion facility for the CVP/SWP under this Option. Water delivery reliability and facility operations are afforded greater flexibility by the ability to opportunistically draw water

from either the facility at Hood or the Victoria Canal siphon. The flexibility of Option 3 is greatly improved over Option 4 due to the ability of CVP/SWP facilities to capture a portion of flows, specifically Rio Vista-required flows, San Joaquin River flows, and Mokelumne River flows, at the south Delta diversion. Modeling simulations of Option 3 indicate that approximately 20% of total CVP/SWP exports are derived through the south Delta diversion, despite operating the Hood facility preferentially.

Export water quality would be improved as compared to current conditions, Option 1, and Option 2, but less than Option 4 (Figure 3-2). The improvements in water quality are expected through the direct diversion of better quality Sacramento River water at Hood as compared to the sole south Delta diversion under current conditions, Option 1, and Option 2. The water quality improvements are directly dependent on the mix of Hood and south Delta diversions. Water quality improvements are somewhat less than that indicated under Option 4 because Option 4 exports only high-quality Sacramento River water diverted at Hood.

5.2.1.2 Criterion #9. The relative feasibility and practicability of the Option, including the ability to fund, engineer, and implement

Option 3 has the highest implementation costs and greatest direct effects on the human environment (likely requiring substantial regulatory authorizations), but provides a more flexible approach to addressing the combined goals of species conservation and habitat restoration using practicable technologies.

The technologies for constructing the siphons and aqueducts are proven. There may be, however, some level of technical uncertainty under Options 3 and 2 regarding the design, construction, and operation of the operable barriers. A technical uncertainty common to Options 3 and 4 will be the ability to construct a state-of-the-art fish screen that will successfully reduce entrainment at the intake of the peripheral aqueduct to negligible levels. Cost practicability of this Option is addressed in Criterion #10, below.

The potential habitat restoration area under Option 3 is expanded over Option 1, specifically in areas along Old River. However, technical uncertainties are associated with habitat restoration along Old River that affect the feasibility of conservation actions in this location. These uncertainties include the unknown effects of reduced water quality (e.g., higher salt and selenium content) associated with concentrating San Joaquin River discharge into the habitat restoration area, and how best to manage flow conditions (e.g., residence time and fluctuating salinity) in the central Delta west of the proposed Option 3 barriers to provide ecological benefits. The geographic area for habitat restoration under Option 3 is more narrowly focused than under Option 4, limiting the flexibility in choosing the most cost effective and ecologically effective restoration sites. Options 2 and 3 include the same geographic area for habitat restoration and are, therefore, comparable regarding the feasibility of physical habitat restoration actions.

5.2.1.3 Criterion #10. Relative costs (including infrastructure, operations, and management) associated with implementing the Option

Delta Infrastructure Costs

Option 3 is expected to have the highest infrastructure costs among the four Options, though under certain configurations its costs could be less than Option 4.[4] Under Option 3, conveyance would be via: (1) a peripheral aqueduct with an intake on the Sacramento River; and (2) an improved through-Delta conveyance with operable barriers along Middle River and separated water supply flows from San Joaquin River flows by a siphon. Thus, Option 3 combines the conveyance approaches of Options 2 and 4.

The key issues in assessing infrastructure costs for Option 3 are:

1. The sizing of the peripheral aqueduct;
2. The extent and degree of levee strengthening assumed for improved through-Delta conveyance;
3. Whether through-Delta conveyance would involve screening the Delta Cross Channel and Georgiana Slough; and
4. The relocating the CCWD intakes.

The evaluation of criterion #10 for Option 2 in Section 4 provides a discussion of the costs of the latter two potential additions.

Tables 5-1 and 5-2 show a range of possible configurations and associated costs for Option 3. The configurations differ by peripheral aqueduct size, degree of levee strengthening, and presence or absence of Delta Cross Channel and Georgiana Slough screening and CCWD intake costs. Table 5-1 excludes costs for Delta Cross Channel and Georgiana Slough screening and CCWD intake costs, while Table 5-2 includes them. Option 3 costs shown in these tables are constructed as follows:

- Peripheral Aqueduct Sizing: Costs are provided for three aqueduct sizes: 5,000, 10,000, and 15,000 cfs.
- Low Cost Estimate: The low cost estimate assumes levee strengthening is limited to bringing Middle River levees between Medford Island and the siphon up to the PL 84-99 standard and uses the lower end of the cost range for the peripheral aqueduct.
- Medium Cost Estimate: The medium cost estimate assumes levees along Middle River between Medford Island and the siphon are brought up to the urban standard and uses the mid-point of the cost range for the peripheral aqueduct.[5]

[4] For example, Option 4 costs could exceed Option 3 costs if (1) Option 4 sized the peripheral aqueduct at 15,000 cfs while Option 3 sized it at 5,000 cfs and (2) Option 3 levee strengthening costs were kept to a minimum.

[5] The urban standard used in the DRMS Phase II evaluation is based on the following levee design: Maximum waterside and landside slopes 3H:1V; Minimum crest width 20 feet; Minimum 3.0 feet of freeboard above 100-year flood stage.

- High Cost Estimate: The high cost estimate assumes levees along Middle River between Medford Island and the siphon are seismically upgraded and uses the upper end of the cost range for the peripheral aqueduct.

Tables 5-1 and 5-2 do not exhaust the universe of Option 3 configurations, but provide a representative range of possible Option 3 configurations and costs. They show costs for this Option ranging between $2.8 and $8.7 billion, with a mid-range cost of about $5.4 billion.

Table 5-1. Expected Infrastructure Costs for Various Configurations of Option 3 (Millions 2007 dollars)

Peripheral Aqueduct Capacity (cfs)	Low	Medium	High
5,000	2,830	3,760	5,945
10,000	3,530	4,660	7,045
15,000	4,130	5,460	8,045

Table 5-2. Expected Infrastructure Costs for Various Configurations of Option 3, with Delta Cross Channel/Georgiana Slough Screening and CCWD Intake Costs (Millions 2007 dollars)

Peripheral Aqueduct Capacity (cfs)	Low	Medium	High
5,000	3,530	4,460	6,645
10,000	4,230	5,360	7,745
15,000	4,830	6,160	8,745

Delta Conveyance Disruption Costs

Risks to water exports from major flood or seismic events are expected to be lowest under Option 3. Option 3's dual conveyance approach would provide a redundancy in the conveyance system, which is lacking in the other three Options. The peripheral aqueduct would reduce the vulnerability of Delta exports to seismic and flood events pulling large amounts of salt water into the south Delta. DRMS Phase I estimated a greater than 50-50 chance in the next 25 years of such an event resulting in disruption of Delta exports for ten months or more given existing Delta conveyance (Option 1). It estimated a 30 to 40% chance of a disruption to Delta exports lasting up to two years. The through-Delta conveyance component of Option 3 would significantly reduce these risks by providing conveyance redundancy. In essence, the two conveyance approaches would serve as backup systems to one another. Additionally, the DRMS Phase II report noted that a peripheral aqueduct, if designed with turnouts to the south Delta, could also facilitate recovery efforts by providing additional fresh water to the south Delta for flushing out brackish floodwater. Option 3 is, therefore, expected to have the lowest conveyance disruption costs of the four Options.

Export Water Quality Costs

It is assumed that the peripheral aqueduct would convey most water for export under Option 3 and that through-Delta conveyance would be used more opportunistically. Hydrodynamic modeling results for Option 3 based on an 80/20 export split between aqueduct and through-

Delta conveyance facilities indicate that Option 3 could lower total dissolved solids in export water by approximately 125 to 150 mg/L.[6] Modeling results indicate export water quality under Option 3 would improve relative to Options 1 and 2, but would be somewhat worse relative to Option 4.

Water quality improvements under Option 3 would benefit agricultural and urban users of exported Delta water. Urban users would benefit from reduced treatment costs and avoided equipment damage and reduced human health costs. South of Delta agricultural users would benefit to some extent from slower salt buildup in soils and less need for flushing salts from the root zone.[7] Salt loading is of particular concern in Southern California urban areas. A 1999 study of the problem (USBR 1999) estimated a $95 million annual benefit for each 100-mg/L reduction in the total dissolved solids of the region's imported water. Updating regional population estimates and accounting for the share of water imported into the region from the SWP and Colorado River, the annual benefit was estimated to be on the order of $100 million (2007 dollars) per 100-mg/L reduction in SWP total dissolved solids. The present value of avoided salinity damages in Southern California over the next 25 years under Option 3 could, therefore, be on the order of $1.5 to $2.0 billion.[8]

DRMS Phase II noted that a peripheral aqueduct (as in Option 4) could result in some degradation in Delta water quality, particularly in the south Delta. It further noted that a functional dual conveyance arrangement would probably be capable of mitigating these impacts. Thus, Option 3 is expected to result in improved south Delta water quality relative to Option 4.

Habitat Restoration Costs

Because it is assumed the overall amount of habitat restoration would be roughly the same across the four Options (though the locations could differ), restoration cost estimates developed with currently available information would not distinguish Option 3 from the other three Options. While it is recognized that unit costs of restoration may vary to some degree according to the range and location of restoration activity, sufficient information on unit restoration cost differentials is not available at this time to distinguish among the four Options. Thus, habitat restoration costs are not treated as a significant distinguishing feature among the four Options.

[6] This estimate is based on converting EC results for export water quality presented in BDCP-ModelingResults_082707.ppt to total dissolved solids using EC to total dissolved solids conversion equations from http://www.iep.ca.gov/suisun/facts/salin/index.html.

[7] Improved agricultural export water quality benefits would probably be negligible for south-of-Delta farmland. For impaired lands on the west side of the San Joaquin Valley, the binding constraint is drainage. Without improvements to drainage, improvements in the quality of delivered irrigation water would not be expected to significantly improve productivity on impaired lands. For non-impaired lands, improvements to water quality would provide only negligible production benefits, if any. Over the long-run, better water quality could slow salt buildup and reduce the need for flushing salts from the soil. (Mark Roberson, *pers comm.*).

[8] The present value calculation of avoided damages uses a real discount rate of 6.0%, per DWR guidance.

5.3 FLEXIBILITY/DURABILITY/SUSTAINABILITY CRITERIA

5.3.1.1 Criterion #11. Relative degree to which the Option will be able to withstand the effects of climate change (e.g., sea level rise and changes in runoff), variable hydrology, seismic events, subsidence of Delta islands, and other large-scale changes to the Delta

Option 3 is expected to have a greater ability than Options 1 and 2, but less ability than Option 4, to withstand large-scale changes to the Delta that would adversely affect species conservation and covered activities. The levees supporting through-Delta conveyance under Option 3 are at somewhat greater risk of breaching or overtopping during flood events than the levees under Option 2 because Option 2 includes strengthened levees along Middle River and Option 3 does not. Unlike Options 1 and 2, Option 3 provides for alternate conveyance through a peripheral aqueduct should levees fail. The probability of flood-induced levee failures is expected to increase in the future based on predicted future changes in sea level and in changes to river hydrology resulting from climate change (DRMS Draft Stage I 2007). Option 3 is considered to be at less risk than Option 4 because Option 3 has the flexibility to use either of the dual conveyances should one of the conveyances fail.

Risk to Habitat Restoration Actions

Physical and operational habitat restoration actions under Option 3 may be at less risk from seismic or flood events and from the ongoing effects of sea level rise than Option 1, at greater risk than Option 4, and at the same risk as Option 2. Under Option 3, habitat restoration would be focused in the north, central Delta, and Suisun Marsh, and may be more narrowly distributed than under Option 4. A levee failure at or near restoration sites may have a disproportionate adverse effect under Option 3 where restoration sites are more concentrated than under Option 4, in which restoration sites are expected to be distributed over a wider area of the Delta. Similarly, if restoration sites are less geographically dispersed, Option 3 would provide less flexibility than under Option 4 to adjust flow operations at these more concentrated sites in the event of levee failure(s).

Protecting physical habitat restoration against the effects of sea level rise requires restoration sites at higher elevations (sites in the Delta with less subsidence) and with elevation gradients that include an ecotone between tidal and upland habitat (allowing, over decades, the gradual upward elevation shift of all tidal habitats in response to sea level rise). The more limited geographic range available for habitat restoration under Option 3 relative to Option 4 reduces the number and extent of sites with such elevation characteristics that may be available for habitat restoration in the Delta and hence may provide less durability of restored habitat.

Risk to Water Supply Infrastructure

Option 3 would provide more protection to water supply facilities from seismic or flood events and from the ongoing effects of sea level rise than Options 1 and 2. The through-Delta conveyance levees under Option 3 would not be strengthened; consequently, this water supply component of Option 3 is at greater risk than under Options 2 and 4. This risk relative to Option 2, however, is offset because the peripheral aqueduct, which is expected to be engineered to withstand seismic and flood events, would be available for conveyance in the event the ability to convey water using the through-Delta component of Option 3 is disrupted. Because Option 3

includes a peripheral aqueduct similar to Option 4 and additionally includes through-Delta supply for a dual system, Option 3 has greater flexibility than Option 4. Should an unforeseen event require temporary closure of the peripheral aqueduct, Option 3 includes the ability to continue to provide water exports directly from the south Delta.

5.3.1.2 Criterion #12. Relative degree to which the Option could improve ecosystem processes that support the long-term needs of each of the covered species and their habitats with minimal future input of resources

Option 3 may be able to sustain improvements in ecosystem processes through time better than Options 1 and 2 but less than Option 4 for the following reasons:

1. Option 3 may provide a greater amount of habitat to support covered species than under Options 1 and 2, as the dual water transport modes allows for less use of through-Delta pumping.

2. Option 3 may be less sustainable than Option 4 if the operable barriers are determined to present barriers to movement of covered species within the Delta (e.g., sturgeon). If operable barriers are found to be adequately responsive to fishery conditions, then Option 3 may be more sustainable than Options 1 or 2 once operating rules are devised that benefit covered species.

3. Option 3 would be more sustainable through time than Options 1 or 2 because it provides for greater flexibility in managing for a more variable Delta hydrology. Such variability should provide some added benefit in managing for harmful invasive species, reducing recurring costs of Option 3 relative to Options 1 and 2.

4. Option 3 may require greater input of resources and be less sustainable through time than Option 4 because Option 3 limits the area available for restoration of covered species habitat. Thus, there is a reliance of restoration success on a smaller range of habitat improvement or restoration Options.

5.3.1.3 Criterion #13. Relative degree to which the Option can be adapted to address the needs of covered fish species over time

Option 3 is expected to be the more adaptable than Options 1 and 2, but less adaptable than Option 4, to address possible future conservation of the covered fish species for the following reasons:

1. A larger percentage of land area compared to Option 1, but substantially smaller percentage compared to Option 4, within the Delta for restoring high function habitat is available under Option 3 should it be necessary to increase the extent of restored habitat for covered species in the future.

2. The geographic extent of land area that is suitable for habitat restoration is greater than under Option 1, but less than under Option 4; therefore, Option 3 is less adaptable than Option 4 in opportunities to restore habitat in other portions of the Delta that may be required to meet conservation needs of covered species in future.

3. The flexibility to experiment with and adjust Delta hydrology is less constrained than under Options 1 and 2 because the need to maintain a hydrologic barrier to maintain water quality for water supply is not needed when water for export is provided via the peripheral aqueduct. Consequently, Option 3 provides the opportunity for experimenting with flow and water quality conditions (e.g., adjusting operation of the Delta Cross Channel, installing temporary or operable barriers, or augmenting flows to east side tributaries) throughout the Delta during periods that through-Delta conveyance facilities are not in use to identify flow regimes that optimize ecosystem and covered fish species benefits.

5.3.1.4 Criterion #14. Relative degree of reversibility of the Option once implemented

Option 3 is expected to be least practicable among the Options to reverse.

Under Option 3, construction of a peripheral aqueduct with fish screens and construction of attendant in-Delta facilities (e.g., operable barriers and siphon) would entail a substantial investment of capital (see Criterion #10) that would be lost if the facilities were abandoned. Additional costs would be incurred if structures needed to be removed or demolished. Compared to Options 1, 2, and 4, reversing Option 3 would be the least likely to be acceptable to the public because the loss of investment costs would be substantially greater than Options 1 and 2 and somewhat greater than Option 4. Additionally, the costs and land area subject to disturbance (e.g., noise and road closures) that would be associated with removal of the peripheral aqueduct would be expected to be substantial and, if the aqueduct were not removed, some level of ongoing maintenance costs would be required to maintain public safety (e.g., maintenance of fencing and patrolling the abandoned facility).

Taking a different perspective, however, with dual conveyance constructed under Option 3, reversion to a through-Delta-only conveyance approach or to a peripheral-conveyance-only approach, if necessary, could be more rapidly accomplished than under any other Option.

5.4 OTHER RESOURCES IMPACTS CRITERIA

5.4.1.1 Criterion #15. Relative degree to which the Option avoids impacts on the distribution and abundance of other native species in the BDCP planning area

The probability for adverse impacts on other native aquatic species within the Delta is expected to be substantially less compared to current conditions, Option 1, and Option 2, but greater than under Option 4 for the following reasons:

1. During periods of operation south Delta SWP/CVP export facilities under Option 3 entrainment of native aquatic species would result similar to Option 2, but likely less than Option 1 and base conditions because Old River would be isolated from the pump facilities. During periods that the peripheral aqueduct conveyance component of Option 3 is operating, native aquatic organisms could be entrained at the Sacramento River intake. Because the intake would be screened with a state-of-the-art fish barrier to minimize entrainment of aquatic organisms, the level of entrainment of other native aquatic organisms is expected to be less than from the water exported from the south Delta facilities. Consequently, it is expected that the potential entrainment levels of other

native aquatic organisms would be less than under current conditions, Option 1, and Option 2. The potential for entrainment of other aquatic organisms is expected to be greater under Option 3 than Option 4 because under Option 4 water would only be exported from a screened facility on the Sacramento River and no water would be exported directly from the south Delta through the SWP/CVP facilities.

2. Under Option 3, the placement and operation of the barriers along Middle River could impede the movement of other native fish and aquatic organisms to and from the east and central Delta. This would also be a potential impact under Option 2, which includes barriers, but not under Options 1 and 4, which do not include barriers along Middle River. The degree of adverse impact is not known at this time but would be expected to be greatest for species that require such movements to fulfill their lifecycle. Because the barriers are expected to be operable, there is the opportunity to adjust operation of barriers to minimize this potential impact.

3. Potential intertidal and aquatic habitat restoration areas are expanded from Option 1 to include areas in the Delta west of the barriers along Middle River under Option 3. Other native aquatic species could benefit in that portion of the Delta. Technical uncertainties, however, are associated with habitat restoration along Old River that affects the feasibility of conservation actions in this area. These uncertainties include the unknown effects of changes in water quality (e.g., higher salt and selenium content) associated with concentrating San Joaquin River discharge into the habitat restoration area and how best to manage flow conditions (e.g., fluctuating salinity) in the central Delta west of the proposed barriers to provide ecological benefits.

4. Construction of barriers, siphons, and a peripheral aqueduct and attendant facilities could result in temporary impacts on water quality associated with sediment discharge or mobilization of channel bed sediments and disturbance to or mortality of aquatic organisms associated with in-channel operation of equipment. These impacts are expected to be temporary and minor, but would be greater than under Option 1 which does not include any construction activities. Similar types and levels of impacts would be expected under Options 2 and 4 with construction of barriers and siphons and strengthening of levees under Option 2 and construction of a peripheral aqueduct and attendant facilities under Option 4.

The potential for Option 3 impacts on native terrestrial species could result from removal of terrestrial habitats and temporary disturbances (i.e., visual and noise) to wildlife associated with construction of a peripheral aqueduct and attendant facilities, siphons, and barriers. The probability for adverse impacts on terrestrial native species within the Delta is expected to be greatest under Option 3 compared to the other Options for the reasons described below:

1. The probability of impacts on native terrestrial species is expected to be substantially greater than under Options 1 and 2 because no ground-disturbing activities would occur under Option 1 that could affect wildlife and their habitats, and construction of the peripheral aqueduct component of Option 3 would remove a greater amount of habitat and result in greater levels of construction-related disturbance than Option 2. Construction of the peripheral aqueduct and attendant facilities could remove a substantial amount of upland, riparian, wetland, and agricultural land cover types that

support habitat for special-status (e.g., greater sandhill crane and Swainson's hawk) and other native wildlife (e.g., waterfowl). For example, up to about 1,200 acres of these habitats were estimated to be removed with construction of the peripheral aqueduct evaluated by CALFED (CALFED 2000). Because the peripheral aqueduct is a linear facility, habitat would be removed in a relatively narrow band along the east side of the Delta. Consequently, the effects of habitat removal on most terrestrial species are expected to be minimized because habitat would be removed as relatively small patches over a large area and would be restored wherever practicable.

2. Both Options 3 and 4 include construction of a peripheral aqueduct and attendant facilities. However, because Option 3 also includes construction of barriers and a siphon to support its through-Delta conveyance component, impacts of Option 3 are expected to be marginally greater to terrestrial habitats than under Option 4. Construction of the siphon and five barriers could result in temporary disturbances (i.e., visual and noise) to wildlife. Impacts on wildlife habitats are expected to be relatively minor because the construction footprint of barriers and the siphon would be relatively small and impacts would be limited to areas immediately adjacent to affected channels. For example, five gates proposed under the SDIP would result in removal of less than five acres of terrestrial habitat (Department of Water Resources and Reclamation 2005).

3. Construction of the peripheral aqueduct would create a new barrier in some areas to the movement of some species of wildlife that currently use or occupy habitats on both sides of the potential alignment of the peripheral aqueduct. This impact would be common to both Options 3 and 4. The level of this impact would be relatively minor in locations where movement of wildlife is currently constrained by other barriers (e.g., Interstate 5, other roadways, and Delta channels and sloughs).

4. As shown in Figure 3-3, salinity in the west-central Delta under Option 3 could increase during the growing season compared to current conditions. This level of potential change in salinity, however, is not expected to affect crops yields sufficiently to reduce their value as foraging habitat for wildlife (Lund et al. 2007). For example, research conducted by Hoffman et al. (1982) indicated that yields of field corn in the Delta were not affected by salinities of less than 3.7 mS/cm.

5.4.1.2 Criterion #16. Relative degree to which the Option avoids impacts on the human environment

The types of adverse impacts as defined under CEQA and NEPA on the human environment that could be associated with Option 3 are described below.[9] Potential impacts described here for Option 3 would not necessarily be significant or could be expected to be reduced to a less than significant effect with CEQA/NEPA mitigation.

[9] The evaluation of Criterion #16 focuses on the likely range of adverse direct and indirect impacts of the Options in the planning area and not the indirect impacts to water quality and water supply reliability and in the service areas. These issues in the service areas are addressed in Criteria #8 and #11. Options 3 and 4 are expected to be substantially less vulnerable than Options 1 and 2 to future disruption of water supply. Export water quality improvements would be successively greater and attendant impacts on treatment costs, agricultural production, and human health successively reduced under Options 1, 2, 3, and 4 in that order.

Option 3 is expected to have the potential for the largest impacts among the Options within the following NEPA/CEQA impact categories because the extent of construction-related activities that could impact these categories are greater than the other Options:

- Geology and soils—risk for erosion,
- Cultural resources—likelihood for encountering cultural resources,
- Air quality—PM10 emissions associated with ground disturbance and operation of equipment,
- Noise—operation of equipment,
- Utilities and public services—likelihood for affecting utility infrastructure, and
- Energy usage—fuel and electricity used in construction.

Water Quality/Hydrology

The quality of water, as measured by EC, that would be exported from the SWP/CVP facilities under Option 3 would generally be expected, within the range of modeled operations, to be substantially higher than under current conditions and Option 1; generally lower than or similar to Option 2 from August through December and higher from January through July; and substantially lower than Option 4 from May through January and similar to Option 4 from February through April (see Figure 3-2). Improvements in water quality exported from the Delta relative to current conditions and Option 1 would be expected to reduce water treatment costs to meet water quality standards and needs for municipal, agricultural, and residential uses in service areas. Because Option 3 includes facilities to export water using through-Delta facilities or a peripheral aqueduct, the flexibility likely exists to adjust operations between the two conveyance facilities to further improve water quality for export, if needed.

Within the Sacramento River delta (as measured at Emmaton on Sherman Island) and the range of modeled operations most likely to achieve water supply objectives, water quality under Option 3 would generally be lower than Option 1 and compared to current conditions from October through May and generally lower than or similar to Option 1 and current conditions from June through September; generally lower than Option 2 in all months; and generally lower than Option 4 from September through February and higher than or similar Option 4 from March through August. Water quality would be expected to be somewhat higher in the east Delta under Option 3 than under Options 1 and 4 because Option 3 would prevent lower quality San Joaquin River water from entering the east Delta (see Figure 3-4). Changes in Sacramento River water quality are expected to have no or minimal impacts on farming practices or production.

Within the San Joaquin River Delta (as measured on Old River at State Highway 4) and the range of modeled operations most likely to achieve water supply objectives, water quality under Option 3 would generally be lower than Option 1 and current conditions from December through August and similar to or higher than Option 1 and current conditions from September through November; similar to Option 2 in all months; and similar to Option 4 from September

through June, but lower than Option 4 during July and August(see Figure 3-4). Changes in water quality in the west-central Delta under Option 3 potentially could affect farming practices or production. Because Option 3 includes operable barriers along Middle River, it provides for operational flexibility to adjust operation of the barriers to improve water quality conditions in the west central Delta, if needed.

Potential impacts associated with construction-related localized and temporary erosion and runoff of sediments into adjacent Delta waters that could temporarily degrade water quality would be greater than Options 1 and 2 because impacts associated with construction of a peripheral aqueduct would be substantially greater than construction-related impacts of those Options. The construction-related impacts of Option 3 would only be marginally greater than Option 4, which does not include construction of operable barriers or the siphon on Victoria Canal.

Aesthetics

Option 3 would have the greatest visual effects because more facilities would be built than for any of the other Options. The barriers, once installed, may be visible from roads and would be visible from boats. The peripheral aqueduct in Option 3 would affect the visual character of the area along its entire length, including the new bridges and siphons needed for east-west passage of traffic, water, and other utilities. Any lights associated with the new facilities could increase night lighting and glare (DWR 2005) at more locations than for the other Options.

Hazards/Hazardous Materials

Option 3 would have the greatest potential for spills of fuel and lubricants as a result of equipment operation and maintenance during construction of new facilities compared to the other Options because more new facilities would be built. Construction activities under Option 3 would have the greatest potential of all the Options to expose people to hazardous materials and waste uncovered during the other Options. The peripheral aqueduct in Option 3 could pose a safety hazard to people who attempt to fish or otherwise use the aqueduct; these effects would be the same as for Option 4 and would not occur in Options 1 and 2.

Transportation/Traffic

Option 3 would likely have substantially greater impacts on transportation and traffic than Options 1 and 2 because it includes construction of a peripheral aqueduct and attendant facilities. Because the aqueduct would be a linear structure, it is expected to result in a substantial disruption of existing transportation infrastructure and traffic patterns by temporarily adding traffic to Delta roadways and potentially requiring modification or rerouting of transportation facilities (e.g., State Highways 4 and 12, local roadways, and railroad lines). Option 3 impacts on transportation and traffic are expected to be similar to Option 4 because construction of the through-Delta facilities under Option 3 is expected to have minimal impacts.

Recreation

Option 3 would likely have the most impacts on recreation among the Options because construction of barriers and siphons could result in temporary or permanent impacts on recreational patterns (e.g., restricting boat access to channels) and construction of a peripheral aqueduct could impact access to lands used for recreational activities or reduce the quality of recreational experiences. Option 1 is not expected to affect recreational uses of the Delta, impacts of Option 2 would be less than Option 3 because it does not include construction of a peripheral aqueduct, and impacts of Option 4 would be somewhat less than Option 3 because it does not include construction of barriers and the siphon at Victoria Canal.

Agricultural Resources

Because the construction footprint of Option 3 is substantially larger, it is expected to result in a greater loss of agricultural land than Options 1 and 2. Construction of a peripheral aqueduct and attendant facilities could remove a substantial amount of agricultural land from production. For example, removal of 700 to 900 acres of agricultural land was estimated to be necessary for construction of the peripheral aqueduct evaluated by CALFED (CALFED 2000). Because the peripheral aqueduct is a linear facility, it is expected to affect multiple landowners. Consequently, the likely impact of removing land from production would be distributed among a number of individual farmers, thus minimizing the extent of impact on individual farmers. Impacts of Option 3 could be greater if irrigation water quality is lowered sufficiently to reduce agricultural productivity in the central-west Delta. This potential impact, however, may be reduced if there is sufficient operational flexibility to manage the operable barriers along Middle River to improve water quality west of the barriers.

Impacts of Option 3 are expected to be similar to Option 4 because the impacts of constructing the through-Delta component of Option 3 would be relatively small and the footprint of the peripheral aqueduct component is expected to be similar to Option 4.

Option 3, however, potentially could have greater impacts than Option 4 on agriculture in the west-central Delta if water quality under Option 3 is sufficiently lower than Option 4 during July and August to affect crop production.

Environmental Justice

Unlike Options 1 and 2, construction of a peripheral aqueduct and attendant facilities under Option 3 would remove Delta land from agricultural production and, therefore, would be more likely to create disproportionate health or environmental effects on minority or low-income populations through this mechanism. Environmental justice-related impacts of Option 3 would be similar to Option 4 because both Options include construction of a peripheral aqueduct and attendant facilities and impacts associated with the through-Delta component of Option 3 would be minimal.

5.4.1.3 Criterion #17. Relative degree of risk of the Option causing impacts on sensitive species and habitats in areas outside of the BDCP planning area

Adverse or beneficial effects on native species and habitats outside the planning area could result from changes in flow regimes downstream of the Delta in Suisun Bay and Marsh and upstream in the Sacramento River and its major tributaries. The potential for adverse effects downstream of the Delta are indicated by differences in Delta outflow among the Options and the potential for adverse effects in the Sacramento River and its tributaries are indicated by differences in end-of-September reservoir storage volumes, which is a measure of the capacity of reservoirs to provide for cold water releases to sustain water temperatures within ranges favored by native aquatic species.

Based on preliminary analyses, the potential for beneficial effects of Option 3 on species and habitats downstream of the planning area is expected to be greater compared to current conditions and Options 1 and 2 because the average annual modeled Delta outflow (20,289 cfs) is higher under Option 3 than these Options and base conditions (about 15,000 cfs). The average annual Delta outflows and benefits to native species and habitats under Option 3 is expected to be similar to Option 4 (20,996 cfs), with Option 3 generally providing for slightly higher outflows in March and April than Option 3 in all water year types.

Under the range of modeled operations, Option 3 is not expected to affect upstream river water temperature conditions relative to current conditions and could provide for cooler releases from Oroville Reservoir compared to current conditions during critical water years. Based on reservoir storage volumes at the end of September, the ability to provide for cold water releases downstream of Shasta, Folsom, and Oroville Reservoirs under Option 3 would be expected to be similar to Options 1, 2, and 4 in most water-year types. During critical water years, Shasta Reservoir storage volume would be less than Options 1 and 2 and similar to Option 4; Folsom Reservoir storage volume would be similar to Options 1 and 3, but greater than Option 4; Oroville Reservoir storage volume would be similar to Options 1 and 2 and greater than Option 4 during dry years; and during critical years, Oroville Reservoir storage volume would be similar to Option 2 and greater than Options 1 and 4.

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